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OF

COMPARATIVE ZOÖLOGY,

AT HARVARD COLLEGE, CAMBRIDGE, MASS.

The gift of the Manchester Geological Society

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Mar. 30, 1889 - Oct. 2. 1890

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTIETH.

PARTS I.—XXI. 1888-89-90.

MANCHESTER:
SOLD AT THE ROOMS OF THE SOCIETY,
36, GEORGE STREET, MANCHESTER.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XX. SESSION 1888-9.

The ANNUAL MEETING of the Members was held on Tuesday, the 9th October, 1888, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

JOSEPH DICKINSON, Esq., F.G.S., the retiring President, in the Chair.

The Chairman called upon the Hon. Secretary, Mr. MARK STIRRUP, to read the Annual Report:—

REPORT OF THE COUNCIL

FOR SESSION 1887-8.

The Council of the Manchester Geological Society in presenting their report to the members for the Fiftieth year of the Society's existence think it desirable to refer to its origin and commencement and shortly to review its history, as recorded in its minute books and publications.

The Society was founded under the name of the Manchester Geological Society by a resolution passed at a meeting of friends of Geological Science held on the 15th of October, 1838, at the York Hotel, King Street, now pulled down, on the site of which stands the new building of the Manchester and County Bank, Limited.

This meeting was presided over by Lord Francis Egerton, afterwards the first Earl of Ellesmere, and the objects of the Society's foundation were then declared to be "To investigate the Mineral Structure and Organic remains of the earth, to enquire into the statistics and machinery of mining,

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to collect books, sections, maps, models and mining records, to publish the Transactions of the Society with suitable illustrations, and to form a museum to be open gratuitously to the public."

So began the Society, and among its original members may be found the names of not a few of the most prominent and distinguished inhabitants of Manchester and the surrounding districts.

The list of officers, published 1841, at the end of the first volume of the Society's Transactions, reads as follows :—

OFFICERS, 1840-41.

PRESIDENT:

The Right Honourable Lord Francis Egerton, M.P., F.G.S.

VICE-PRESIDENTS:

James Heywood, Esq., F.R.S. & G.S.
Ralph Thicknesse, jun., Esq.
William Hulton, Esq., F.G.S.
John Eddowes Bowman, Esq., F.G.S. & L.S.

TREASURER:

George Wareing Ormerod, Esq., M.A., F.G.S.

AUDITORS:

Thomas Kirkman, Esq.
Samuel Elsworth Cottam, Esq., F.R.A.S.

HONORARY SECRETARIES:

Edward William Binney, Esq.
John Frederic Bateman, Esq.

ORDINARY MEMBERS OF THE COUNCIL:

James Black, M.D., F.G.S.
Captain Brown, F.L.S. M.W.S.
George Watson Buck, Esq.
Charles Clay, Esq.
Matthew Dawes, Esq., F.G.S.
William Fairbairn, Esq.
John Hawkshaw, Esq., F.G.S.
Eaton Hodgkinson, Esq., F.R.S.
Francis Looney, Esq., F.G.S.
Edmund Lyon, M.D.
William Mellor, Esq.
John S. Newbold, M D.
John Ogden, Esq.
William Peace, Esq.

BANKER:

Sir Benjamin Heywood, Bart., and Co.

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and among other Members of that time are the well-known names of Dr. R. F. Ainsworth, Elkanah Armitage, Thomas Ashton, Edmund Ashworth, R. W. Barton, Hugh Beever, Edmund Buckley, W. R. Callender, Richard Christy, Peter Clare, James Crossley, S. D. Darbishire, Sir Philip Egerton, and his life-long friend, the Earl of Enniskillen, Dr. Fleming, Samuel Fletcher, Robert Hyde Greg, W. Rathbone Greg, George Hadfield, Joseph Heron, Sir Benjamin Heywood, Paul Moon James, Thomas Knowles, William Langton, Edward Loyd, William Nield, Edward Stanley, Bishop of Norwich; H. M. Ormerod, Mark Philips, M.P.; G. S. Fereday Smith, Edward Tootal, Henry Tootal, Lord Vernon, and many others of equal note.

The Council were for some time engaged in arranging for a habitation, which was eventually found at 25, Faulkner Street, and in receiving donations of Minerals and Fossils.

Their first Annual Meeting was held in the Rooms of the Royal Institution, Mosley Street, on the 17th January, 1839, under the presidency of James Heywood, Esq., F.R.S., whom they are happy to say, with about four other members, still survives.

At the end of this year Mr. Heywood offered the greater part of his house in Mosley Street, at the corner of St. Peter's Square (now the Clarendon Club), at a trifling rent, and the Society moved thereto.

This was not the only instance of Mr. Heywood's liberality to the young Society, for, besides giving £100 in 1839 to the initial expenses, he gave in 1841 a collection of fossil shells from the Carboniferous Limestone, made by Mr. Gilbertson, of Preston, and also in 1842 he presented to the then growing museum belonging to the Society, a large

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general collection of fossils, made by George Cumberland, Esq., F.G.S., of Bristol, for which he gave £400.

These gifts formed the nucleus of the large collections which were afterwards got together.

It ought not to pass unrecorded that the magnificent specimen of *Ichthyosaurus communis*, now in the Owens College Museum, from the Lias of Whitby, perhaps the finest example of one of these fossil reptiles in the kingdom, was presented to the Society by the joint liberality of George Hadfield, Esq., M.P. for Sheffield, and James Heywood, Esq., F.R.S., and was afterwards set up at the expense of the Society by the late J. Waterhouse Hawkins.

The rapidly increasing collection of fossils was moved into Mr. Heywood's house, and a commencement was made to arrange and name the specimens.

In the year 1840, the Society, with other bodies, presented a Petition to the Houses of Parliament, asking for the Ordnance Survey to be enlarged from one inch to six inches to the mile. The Treasury, in October, wrote to say that the Petition was granted as to South Lancashire, and the Master-General of the Ordnance was pleased to say that the arguments used in the Society's Petition were a principal ground of granting the request. At the end of this year the Society consisted of 134 members. The rules of the Society had been drawn up. Papers were regularly read—followed by discussion—and the Society was now in working order, and in March, 1841, preparations were made for publishing, and the first part was published before October of that year.

The British Association visited Manchester, for the first time, in 1842, and materially assisted the Society by a

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grant of £100 from its funds towards arranging the collection.

In 1849 the Museum of the Society had been moved into the Manchester Royal Institution and the meetings held there for some years, but the number of members had greatly fallen off and also of those attending the meetings, and in October of that year the Council addressed a strong remonstrance to the members and it was resolved that a Committee should be appointed to reorganize the Society. In 1850, negociations were opened for amalgamating the collection and the Society partially with the Natural History Society, and in November this was arranged. The two Geological Collections were gradually amalgamated and Meeting rooms and other accommodation provided in the building of the Natural History Society, Peter Street, and this was carried out partially by October, 1851, and completed in October, 1852, when the Curator reported it to be complete, and that the rearranged and amalgamated Collection was ready for the gratuitous admission of the public. The arrangement of the Collection was further continued in 1854, with the assistance of Mr. Salter of the Government Museum, Jermyn Street, especially as to the Silurian and Carboniferous Limestone fossils.

The Council now hoped that having secured convenient rooms for meeting, having by joining the two collections formed one excellent one, having greatly reduced the expenses which had weighed so heavily on them, they might hope to make more successful progress. This arrangement continued until 1869, subject to a good deal of disagreement, misunderstanding, and discomfort.

The Society continued its meetings in the building of the Natural History Society in Peter Street until 1873, with a steadily increasing number of members.

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In the year 1869, after much discussion and consideration, in consequence of the Natural History Society having agreed to give their building for certain purposes, and partly to the Owens College, the Geological Society agreed to concur with the Natural History Society, thereby representing the united collection, to present it to the Owens College, subject to certain stipulations as to maintenance and care, the free admission of members and of the public on certain days, and that the College should provide a fitting building for the museum. The Society also agreed with the Literary and Philosophical Society to have accommodation for their meetings and Council meetings in the rooms of that Society in George Street. The collection was removed to Owens College in 1873, and on the 18th November, 1873, the General Annual Meeting of the Society was held in the rooms of the Literary and Philosophical Society, and the library was removed to a place provided in the same building by the same Society.

The Society has from this time in most things made a continued steady advance. Many valuable papers have been read, especially relating to the Colliery Department of Geology, and the reports have been steadily printed.

The number of members continued to advance, and if at present under the cloud of bad trade, it has not progressed still more, there is no reason to doubt a future increase.

The Council also have carefully invested as opportunity offered, the surplus revenue and compositions, so that at present the reserve fund so invested, exceeds in value £1000.

The Library has been largely increased by purchases, exchanges, and donations, and the Literary and Philosophical Society have liberally provided greatly improved accommodation for the same.

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By the agreement of 1869, the Owens College authorities agreed to find suitable accommodation for the large united geological collection, and in the new buildings in Oxford Road, they have admirably redeemed their pledge. The Collection re-arranged, re-named, by Professor Boyd Dawkins and his assistants, is now open to view in a lofty spacious well-lighted room of 90 feet in length, with the minerals immediately adjoining, accessible in every part. This Museum was opened last year, and it is believed not to be surpassed by any Museum in the United Kingdom in the above qualities.

The Meetings have been held, not always in Manchester, but occasionally at Wigan, and Field Excursions have, from time to time, been made to other places.

The Council, in now closing their retrospect, hope that the peaceful and prosperous progress of the Society, to judge from the last fifteen years, is established; and they believe, that on comparison of the primary resolution at the meeting founding the Society, it will be found that the objects there declared, have been fully and effectually carried out.

Although the past half century has witnessed periods of growth and decline in the activity of the Society, such as are inevitable to organizations like our own, this Jubilee year, your Council have pleasure in stating, shows no signs of decadence or loss of vitality, but rather seems to have witnessed a renewal of its vigorous youth, in the more than the average number and quality of the papers that have been brought before the meetings.

These communications, 29 in number, of which a list is appended, have been varied in character, ranging from purely theoretical subjects in geology, to those more practical applications of geological science, which have for their

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object mining, or the extraction and utilization of the mineral wealth, with which our rocks are stored.

Some of the subjects, which have been discussed, are especially noteworthy, as matters affecting large commercial interests, and, in some degree, our national prosperity.

In accordance with a request in the last Annual Report, that the Society should take up some definite work in connection with one or other of the Committees of the British Association, formed for scientific investigations, your Council are pleased to state that a commencement has been made by a few of the members in collecting information as to the distribution of erratic blocks in the Lancashire and adjoining districts, a portion of which information has already been embodied in a Paper read before the Society during the past Session.

The number of members on the roll shows some slight diminution, owing to the vacancies, caused by resignations and deaths, not having been equalled by the number of new members elected.

During the year, 9 new members have been added to the list, 9 have resigned, and 4 have died. Among the latter the Council have to regret the loss of John Ross Coulthart, Esq., J.P., F.R.S., formerly of Ashton-under-Lyne, a member of nearly 30 years standing, also F.V. Hayden,Esq., the eminent geologist of the United States' Geological Survey, who was an honorary member of the Society. The list of members is now composed of:—Honorary members 16, Life members 8, Ordinary members 190, making a total of 214.

The usual number of meetings has been held during the session, including two in the Mining School, Wigan, and a special evening meeting at the New Museum, Owens College,

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on the invitation of the Principal and Council of the College.

A more numerous attendance of the members was noticeable at the Wigan meetings, which the Council hope will continue, and that the members will evince their interest in them by providing interesting and valuable matter for discussion.

The meeting at Owens College was largely attended by the members, who had at last the satisfaction of seeing the geological collections formerly belonging to the Society, nobly housed and in the process of being arranged and displayed in the spacious hall allotted to them.

Your Council have to thank the authorities of the College for the courtesy extended to the members, of inviting them, before the formal opening of the Museum buildings to the public, to inspect what they had already done in the Geological department, to fulfil the conditions which had been entered into, when the transfer of the Society's collections took place.

Your Council are pleased to see the continued interest taken in these geological collections by many of the members, an interest which has been evinced by contributions during the past year from Messrs. J. Dickinson, C. Dugdale, H. M. Ormerod, Miles Settle, M. Stirrup, H. A. Woodward, and others.

The collections relating to our local geology, especially the flora and fauna of our coal measures, are far from being as complete as they might be, and the Council would therefore impress upon the members, many of whom have exceptional opportunities, of the desirability of making the museum as representative and instructive as possible of the geology of the Lancashire coal-field.

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Two excursions have been made during the summer, both on the invitation respectively of two of our members.

The first took place on the 26th July, under the direction and leadership of Daniel Adamson, Esq., J.P., F.G.S., to the Frodingham Iron Field, Lincolnshire, a district with whose industrial development Mr. Adamson's name is closely connected.

The members on their arrival at Frodingham were conducted over the works of the North Lincolnshire Iron Co., of which Mr. Adamson is Chairman; the process of iron making being pointed out, with the special arrangement of the blast furnaces, and the utilization of the gas from the smelting operations for the heating of a number of boilers and stoves.

After some time spent upon the works, the party proceeded to examine the iron-stone beds which crop out in the vicinity. These belong to the Liassic formation, and lying close to the surface, are worked open cast near the outcrop.

The ironstone occurs interstratified with a bastard limestone full of fossils of mid-Lias age, of which abundant collections were made.

The Second Excursion on August 16th, to the Warburton section of the Manchester Ship Canal Works, was carried out under the auspices of the Chief Engineer of the undertaking, E. Leader Williams, Esq., M.Inst.C.E., who, though unfortunately unable to be present to lead the party himself over the works, had arranged for efficient substitutes in the persons of Mr. Prowse, the contractor's agent, and Mr. Brown, the resident Engineer. Mr. C. E. de Rance of the Geological Survey also joined the party, and was of service in explaining the geological features of the district.

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The interest taken in this great engineering enterprise was shown by the presence of a large number of the members. The section examined was from Hollins Ferry to Thelwall, the excavations being mainly in alluvial beds of the old river valley and in drift deposits, except at Warburton, where some hard beds of Keuper Marls, which rest immediately upon the Keuper Waterstones, were being blasted for the readier attack of the steam "navvy." The inspection of these marvellous machines at work lent great interest to the day's proceedings.

The Library still continues to receive valuable accessions by exchange, gift, and purchase. During the year attention has been given to supplying the deficiencies in several of the sets of publications issued by the more important societies with which exchanges are made. Applications for missing numbers have, for the most part, been generously supplied, thus filling blanks that militated against the usefulness of the library.

In accordance with a resolution passed last year, a number of serial publications, amounting to upwards of 100 volumes, have been bound up. Attention has also been given to the preparation of a new catalogue, which had become necessary owing to the large additions of recent years. This has now been completed in manuscript, and the advisability of its early publication will be a matter for the determination of the new Council.

Among donors to the library are the Governor-General of India in Council for a complete set of the Quarterly Record of the Geological Survey of India, and Messrs. W. Whitaker, F.G.S., and Joseph Dickinson, F.G.S., for other contributions.

The following purchases have been made in addition to the usual subscription volumes, viz.:—

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Vol. 2, in two parts, of the Memoirs of the Geological Survey of Great Britain (to replace missing volumes).

Palæontology of the State of New York, by James Hall. Five vols. in seven. Quarto.

Geological Record for 1879.

Handbook of Scientific and Learned Societies of Great Britain and Ireland, 1888.

The Treasurer's Statement is a gratifying document, showing the finances of the Society to be in a sound and prosperous condition.

Notwithstanding rather heavier disbursements than usual on the printing of the Transactions and their illustration, also a special outlay on account of the library, there still remains a good balance in favour of the Society—being about £30 of an increase over last year.

The Council in concluding their Annual Report, and in presenting a short retrospect of the 50 years of the Society's history, trust that the success of the present and the prestige of the past, may induce the members to take a deeper interest in its actual work and future progress.

Your Council encourage the hope that their successors, by a wise and skilful management of the Society, may be able to extend the sphere of its usefulness, and draw within its fold many of those who pursue the study of geology, whether for its intrinsic value as an intellectual regimen, or whether for those more practical and economic advantages which result from a study of its principles and doctrines in their application to mining and kindred industries.

The Treasurer presented the Balance Sheet, which he read, as follows :—

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Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1887-8.	Abstract of Receipts.	£	s.	d.
Oct. 1.—To	Balance brought down, 1887	97	15	1
,,	Birkenhead Dividends	23	6	6
,,	Lancashire and Yorkshire Dividends	11	13	3
,,	Sale of Transactions.....	5	13	6
,,	Subscriptions.....	181	0	0
,,	Arrears	17	0	0
,,	New Half-year's Subscriptions ..	2	0	0
,,	Bank Interest	0	13	5
		£339	1	9
1888.—Oct. 1.—To	Balance brought down ..	127	12	3

1887-8.	Abstract of Papments.	£	s.	d.
By	Postages from last year	3	0	6
,,	Library	14	14	10
,,	Transactions	90	13	11
,,	Reporter.....	10	10	0
,,	Circulars, Stationery, &c.	10	15	0
,,	Postages and Carriage of Parcels	23	6	6
,,	Meetings—Extra Expenses	1	9	1
,,	Binding	11	7	2
,,	Collectors' Commission	10	0	0
,,	Rent, &c.	30	0	0
,,	Insurance	0	12	6
,,	Gift to Mr. Roscoe on retirement	5	0	0
		£211	9	6
,,	Balance carried down	127	12	3
		£339	1	9

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £300 Lancashire and Yorkshire Consoildated Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 30th October, 1888.

CLEGG LIVESEY,
ALFRED PILKINGTON, } Auditors.

HENRY M. ORMEROD, Treasurer.

1st October, 1888.

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It was moved and seconded that the Report of the Council as now read, together with the Treasurer's Balance Sheet (subject to audit) be approved and adopted. Carried unanimously.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE SOCIETY DURING THE SESSION 1887-8.

1887.

November. Dickinson, Joseph. "On the Progress of Mining and Geology."

December. Stirrup, Mark. "On the Conferences of Delegates of the Corresponding Societies of the British Association."

Clifford, William, M.E. "On the Richmond Coal-field, Virginia."

1888.

January. Bainbridge, Emerson, M.Inst.C.E. "On a New Description of Miners' Safety Lamp."

Bramall, Henry, M.Inst.C.E. "On a New Lead Rivet Mould."

Teale, Wm. E. "On an Automatic Lock for Shields or Bonnets of Safety Lamps."

Hall, Henry. "An Improved Tin Can Lamp."

Swete, O. "A New Electric Miner's Lamp."

Edward, G. "On the Old Red Sandstone of Caithness and its Fossils." (Given at Owens College.)

Williamson, Prof. W. C. "On the Fossil Trees of the Coal Measures." (Given at Owens College.)

February. Bolton, Herbert. "Observations on Boulders from the High-Level Drift of Bacup."

Cowburn, Henry. "On Boulders in Coal Seams."

Stirrup, Mark, F.G.S. "On Foreign Boulders in Coal Seams."

March. Hardwick, Chas. "The Granite of the Mullet, Ireland."

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March. Percy, C. M., M.E., F.G.S. "On Mine Rents and Mineral Royalties."

April. Cornish, Vaughan. "On the Artificial Reproduction of Minerals and Rocks."

Woodward, Herbert A. "Boulders in Coal Seams."

Gresley, W. S., Assoc.M.Inst.C.E., F.G.S. "On the Occurrence of Boulders and Pebbles in the Coal Measures."

May. Walmesley, Oswald. "On Mine Rents and Mineral Royalties."

Martin, J. S., F.G.S. "On Mine Rents and Royalties."

Meadows, J. W. C. "On Irish Mine Rents."

Clifford, William, M.E. "On Mine Rents and Royalties."

Ashworth, James. "On Ashworth's Patent Hepplewhite—Gray Safety Lamp."

Moore, J. E. "On Pearson's Patent 'Eclipse' Miners' Safety Lamp."

Mercier, Maunsell, M.E. "On Cunliffe's Patent Hydraulic Coal-Getter."

June. Bird, W. J. "On the South Durham Salt Bed and Associated Strata."

Watts, William, F.G.S. "On the Distribution of Erratics and Boulder Clay on the Lower Portions of the Drainage Areas of the Oldham Corporation Waterworks."

Law, Robert, F.G.S., and Horsfall, James. "An Account of Small Flint Implements found beneath Peat on several Elevated Points of the Pennine Chain, lying between Huddersfield and Oldham."

Sington, Theodore. "On the recently disclosed Sections of the Superficial Strata along Oxford Street, Manchester."

Erratum in Mr. W. S. Gresley's paper "On the the occurrence of Boulders and Pebbles in the Coal-Measures."

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NEW ORDINARY MEMBERS.

Grundy, James
Hallas, George H.
Oldham, Thomas
Oliver, S. A.
Saint, William
Scarborough, George E.
Smith, Sydney A.
Walmesley, Oswald
Wood, William

MEMBERS DECEASED.

Bamford, J. B.
Coulthart, J. Ross
Hayden, F. V.
Wallwork, Thomas

MEMBERS RESIGNED.

Devonport, John
Dugdale, Crispin
Hall, A. D.
Law, Robert
Mc.Kinless, J.
Pearson, A.
Rogers, William
Smith, G. Fereday
Storey, Edgar

ELECTION OF OFFICERS.

The Hon. Secretary called the attention of the members to the rules of the Society by which the annual change of the President becomes necessary, also the retirement of the two Vice-Presidents, and four members of the Council who had attended the fewest number of Council meetings. The election was then proceeded with, and the following Officers and Council were declared duly elected :—

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President:

JOHN KNOWLES, M.Inst.C.E., J.P.

Vice-Presidents:

HENRY BRAMALL, M.Inst.C.E. | GEORGE PEACE.
JOHN S. BURROWS. | ROBERT WINSTANLEY.

Ex-officio Vice-Presidents:

JAMES HEYWOOD, F.R.S. | ANDREW KNOWLES.
G. W. ORMEROD, F.G.S. | G. C. GREENWELL, F.G.S.
R. CLIFFORD SMITH, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.
H. M. ORMEROD, F.G.S.
PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.

Hon. Treasurer.

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

MARK STIRRUP, F.G.S. | G. H. HOLLINGWORTH, F.G.S.

Other Members of the Council:

W. S. BARRETT. | CHAS. PILKINGTON.
H. H. BOLTON, JUNR. | JAMES RADCLIFFE, F.G.S.
R. T. BURNETT, F.G.S. | WM. SAINT, H.M.I.M.
WALTER EVANS. | JAMES TONGE, F.G.S.
C. E. NEWTON, F.G.S. | GEORGE WILD.
GEORGE H. PEACE. | HERBERT A. WOODWARD.

Hon. Auditors.

ALFRED PILKINGTON. | CLEGG LIVESEY.

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Mr. STIRRUP said he wished specially to direct the attention of members to the notices which appeared in the circular convening the meeting, namely:—

"In order to meet the convenience of some of the Members, the Council have changed the date of the Meeting from the first to the second Tuesday of the month, at the usual hour; and they hope that this alteration will enable a larger number of the Members to take part in the proceedings."

"Members desirous of reading Papers, or making short communications during the ensuing Session, will much oblige the Hon. Secs., and facilitate the arrangement of the programme, if they will send in as early as possible the titles of their subjects, and the date they would prefer."

A vote of thanks to the retiring members of the Council having been passed,

Mr. JOHN KNOWLES took the Chair as President for the ensuing year; and in doing so said:—I am exceedingly pleased and gratified, gentlemen, that you have appointed me your President for the ensuing year. It is some 14 or 15 years since I occupied this position, for two years; and since that time no doubt great changes have taken place. Then, in the trade with which I am more immediately connected, the prospects were bright—in fact they were exceedingly bright, and I only hope, now, that we may have somewhat brighter prospects again. With regard to the meetings of this Society, I hope, as Mr. Stirrup has said, we may succeed in bringing more members together who will take an interest in them. It will be observed that the Council have made an alteration in the days of our meeting. The fact of the meetings being on the first Tuesday of the month has prevented me, and no doubt others also, from

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attending; because it is on that day that we have always had the meetings of our Coal Association, in Manchester, and we cannot very well attend both. But on the second Tuesday in the month I think we may hope to see a larger attendance at the meetings of this Society, of gentlemen interested in mining. (Hear, hear.) Again I thank you for having appointed me President, and I trust and hope that we may have a good session. If I may be allowed, now, I should like to move a vote of thanks to our late President, Mr. Dickinson, who always takes an interest in whatever he undertakes, and who during the many years I have known him, has had a desire to encourage geology and mining in this district. Mr. Dickinson does in earnest any work that he undertakes, and as our late President he is well deserving of our thanks.

Mr. Stirrup said: I have much pleasure in seconding the proposition. Mr. Dickinson is one of our most industrious members,—whether as an ordinary member, or more prominently as President; and I can also say for him that his attention to the welfare of the Society is not exceeded by that of anyone connected with it. He has been present, I may say, at every Council meeting, and every ordinary meeting during the past Session, and that notwithstanding the many important engagements which he must have in connection with his official work. This devotion to duty ought to have great influence with other members, and will, I hope, be an incentive to those who may follow in his place.

The vote of thanks was put to the meeting and carried unanimously.

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Mr. DICKINSON having acknowledged the compliment paid to him,

The PRESIDENT made a few remarks on the work of the coming session, which concluded the business of the Annual Meeting.

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APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1887-88.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1886-7 and 1874-75. *From the Society.*

Bristol Naturalists' Society.—Proceedings, Part 2, Vol. V. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Part 7, Vol. XIV., Parts 2-5, Vol. XVI. *From the Institute.*

Cornwall.—Transactions of the Royal Geological Society of. Part 2, Vol. IX. *From the Society.*

Cornwall.—Royal Institution of. Journal, Part 2, Vol. IX. *From the Council.*

Dublin.—Royal Geological Society of Ireland. Journal, Part 2, Vol. XVIII., and Vol. VIII. N.S. *From the Society.*

Edinburgh Geological Society.—Transactions. Part 3, Vol. V. Catalogue of Library. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings, Session 1886-87. *From the Society.*

Edinburgh.—Royal Society of. Proceedings for Sessions 1883-4, 1884-5, 1885-6, 1886-7. *From the Society.*

Essex Naturalist.—Nos. 9-12, Vol. I.; Nos. 1-6, Vol. II. *From the Essex Field Club.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 7 and 8, Vol. IV. *From the Society.*

Leeds Philosophical and Literary Society.—Annual Report, 1887-8. *From the Society.*

Leicester Literary and Philosophical Society.—Transactions. Parts 4-7. *From the Society.*

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Liverpool Geological Association.—Transactions. Vol. VII., Session 1886-7. *From the Association.*

London Geological Society.—Quarterly Journal. Nos. 164, 169, 172-174, Vol. XLIV.; List of Members, November, 1887. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 3-6, Vol. X. *From the Association.*

London Geological Magazine.—Nos. 281-289. *Purchased.*

London Institute of Mechanical Engineers.—Proceedings. Nos. 3-4, 1887; No. 1, 1888; Library Catalogue; Subject Index of Papers, 1847-87. *From the Institute.*

London.—Iron and Steel Institute.—Journal. No. 2, 1887. *From the Institute.*

London.—Palæontographical Society.—Vol. XLI., 1887. *Purchased.*

London.—Geological Record. 1879. *Purchased.*

London.—Year Book of Scientific Societies. 1888. *Purchased.*

London.—Report of British Association.—Manchester Meeting, 1887. *Presented by the Association.*

London.—Royal Institution of Great Britain.—Proceedings, Part 1, Vol. XII. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 258-265, Vol. XLIII. Parts 266-267, Vol. XLIV. *From the Society.*

Manchester Association of Engineers.—President's Address; Pamphlet by W. H. Bailey. *From the Association.*

Manchester Literary and Philosophical Society.—Memoirs, Vol. X. Third series. Proceedings, Vols. 25-26. *From the Society.*

Manchester Field Naturalists' and Archæologists' Society.—Report and Proceedings for 1887. *From the Society.*

Midland Institute of Mining Engineers.—Transactions. Parts 90-95, Vol. XI. *From the Institute.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Part 4, Vol. XXXVI.; Parts 1-4, Vol. XXXVII. *From the Institute.*

North Staffordshire Naturalists' Field Club.—Annual Report and Transactions, 1887. *From the Club.*

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Scotland.—Mining Institute of Scotland.—Transactions. Parts 5-9, Vol. IX.; Parts 1-2, Vol. X. *From the Council.*

South Wales Institute of Engineers.—Proceedings. Parts 4-6, Vol. XV. *From the Institute.*

Warwickshire Naturalists' Field Club.—Proceedings, 1887. *From the Club.*

Yorkshire Geological and Polytechnic Society.—Transactions. Part 3, Vol. IX., N.S. *From the Society.*

Organization of the Fossil Plants of the Coal Measures. Parts 13-14. By Professor W. C. Williamson, LL.D., F.R.S. *From the Author.*

Uber den Einfluss der Luft-druck Schwankungen auf die Entwicklung von Schlagwettern.—Pamphlet from *Mr. Dickinson.*

The following books were presented by W. Whittaker, F.G.S.—

Mémoires de la Société Géologique du Nord.—No. 3, Vol. I., 1882.

Sanitary Institute of Great Britain.—Address to Section 3, 1886.

Chester Society of Natural Science.—Fifth Annual Report, 1875-6.

Miners' Association of Cornwall.—Report and Proceedings, 1871, 1872-3, and 1874-5.

Geological Survey of Alabama.—Report for 1879-80.

Annual Report Californian State Mineralogist, 1884.

ANNUAL REPORTS, FROM THE COMMITTEES.

Cambridge University.—Annual Report of the Library Syndicate, 1888.

Liverpool Free Library and Museum.—35th Annual Report.

Manchester.—Owens College.—Calendar. 1887-8.

Oxford University Museum.—Catalogue of Transactions in Radcliffe Library. 1887.

Salford Museum, Libraries, and Parks.—Annual Report.

CANADA AND U.S. AMERICA.

Canada.—Montreal.—Mc.Gill University. New Species of Fossil Sponges, Canada. *From Sir J. W. Dawson.*

Canada.—Ottawa.—The Canadian Mining Review. No. 10, Vol. V.; Nos. 2-6, Vol. VI. *From the Editor.*

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Canada.—Ottawa.—Geological and Natural History Survey of Canada.—Annual Report, Vol. II., 1886. *From A. R. C. Selwyn, F.R.S., Director of the Survey.*

Canada.—Canadian Institute, Toronto.—Proceedings. Nos. 1-2. Vol. V., 3rd Series; Annual Report, 1887. *From the Institute.*

Californian State Mineralogist.—7th Annual Report, 1887.

U.S.A., Cambridge.—Harvard College.—Annual Report of the Curator of the Museum of Comparative Zoology, 1886-7.—Bulletin of the Museum of Comparative Zoology. Nos. 5-9, Vol. XIII.; Vols. XIV. and XV., Three Cruises of the Blake; No. 1, Vol. XVI. *From Alexander Agassiz.*

U.S.A., Denver.—Colorado Scientific Society.—Proceedings. Part 2, Vol. II. *From the Society.*

U.S.A., Indiana.—Geological and Natural History Survey of. 15th Report, 1885-6. *From John Collett, State Geologist.*

U.S.A. Minnesota.—Geological and Natural History Survey of. 15th Annual Report for year 1886; Bulletin, Nos. 2-4. *From N. H. Winchell, State Geologist.*

U.S.A., New York.—American Institute of Mining Engineers.—Transactions. Index, Vols. I.-XV. in one Vol. *From the Institute.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings. Part 2, April-August, 1887; Part 3, September-December, 1887. *From the Academy.*

U.S.A., Philadephia.—Journal of Franklin Institute. Nos. 742-744, Vol. CXXIV.; Nos. 745-750, Vol. CXXV. *From the Institute.*

U.S.A., Philadelphia.—Pennsylvania Geological Survey. Annual Report, 1886; Part 1, Coal Regions; Part 2, Oil and Gas Regions, with Atlas; Atlas of Western Middle Anthracite Field; Atlas of Bucks and Montgomery Counties. *From the Board of Commissioners.*

U.S.A., Shenandoah.—The Colliery Engineer. Nos. 1-11, Vol. VIII. *From the Editor.*

U.S.A., Washington.—United States Geological Survey. 6th Annual Report, 1884-5; Mineral Resources of United States, 1886. *From the Director of the Survey.*

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U.S.A., Washington.—United States Geological Survey. Coal. By Chas. A. Ashburner. *From the Author.*

INDIA.

Calcutta.—Records of the Geological Survey of India. Vols. 1-20, complete. Part 1, Vol. XXI. *From the Governor General of India in Council.*

AUSTRALIA.

Sydney.—Royal Society of New South Wales. Journal and Proceedings. Vol. XX., 1886; Vol. XXI., 1887. *From the Society.*

New South Wales.—Department of Mines.—Annual Report, 1886. *From the Government.*

Department of Mining.—Geological Survey.—Geology of Vegetable Creek Tin Mining Field, 1887. *From the Survey.*

Victoria.—Gold Fields of. Reports of Mining Registrars. 30th June, 1887; 30th September, 1887. *From the Government.*

Victoria.—Annual Report of Mines and Water Supply.

Victoria.—Mineral Statistics of 1886. *From the Government.*

Victoria.—Natural History of. Prodromus of the Zoology. Decades 1-15. *From Fred. Mc. Coy, F.R.S., Director of the Victoria Museum, Melbourne.*

New Zealand.—Reports of Mining Industries, 1887. *From the Government.*

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 2-4, Band XXXIX. *From the Society.*

Brussels.—Société Malacologique de Belgique. Procès-Verbaux, July to December, 1887. *From the Society.*

Buenos Ayres.—Datos Annales del Comercio Exterior. Nos. 55-56, 1887. *From the Goverment.*

Halle, a/S.—Vereins für Erdkunde, 1887. *From the Society.*

Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 96-97, Vol. XXIII. *From the Society.*

Paris.—Revue de le Legislation des Mines. July-December, 1887; January-June, 1888. *Purchased.*

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Pisa.—Atti della Società Toscana di Scienze Naturali. Memorie. Fasc. 2, Vol. VIII.; Processi Verbali, Vol. VI. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Rendiconti. Fasc. 4-13, Vol. III.; Fasc. 1-8, Vol. IV. *From the Academy.*

St. Petersbourg.—Academie Impériale des Sciences. Bulletin. No. 4, Tome XXXI.; No. 1, Tome XXXII. Memoires. Nos. 2-10, Tome XXXV. *From the Academy.*

St. Petersbourg. — Institut des Mines. Comité Géologique. Mémoires. Nos. 4-5., Vol. II.; No. 3, Vol. III.; Bulletins: Parts 8-10, Vol. VI.; Supplement, Vol. VI. *From the Minister of Domains.*

Stettin.—Jahresbericht des Vereins für Erdkunde, 1887. *From the Society.*

Wien.—Bericht 13 Vereinsjahr verein der Geographen, 1887. *From the Society.*

BOOKS PURCHASED, 1887-8.

Geological Magazine.

Geological Record for 1879.

Natural History of New York: Palæontology. By James Hall. Vols. I.-V. in 7 Vols.; Text and Plates.

Palæontographical Society's Monograph. Vol. XLI. 1887.

Revue de la Legislation des Mines. Paris.

Year Book of Scientific and Learned Societies. 1888.

Societies with whom the Society Exchanges its Transactions, and Institutions and Journals to whom a Copy is sent free.

I.—England.

London.....British Museum.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.

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Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain.
Royal Society, Burlington House, W.

Manchester .....The Manchester Association of Engineers, 18, Hullard Street, Old Trafford.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Society.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association, 36, George Street.

Barnsley .....Midland Institute of Mining Engineers.

Birmingham.....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Burlington Chambers, New Street.

Bristol.....Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Chester.....Society of Natural Science.

Chesterfield .....Institute of Mining Engineers.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.

Tuckingmill, Camborne ....Mining Association and Institute of Cornwall.

Essex .....Essex Field Club, 8, Knighton Villas, Buckhurst Hill, Essex.

Exeter .....Albert Memorial Museum.

Halifax .....Geological and Polytechnic Society of Yorkshire.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Sunny Bank).

Leicester .....Literary and Philosophical Society.

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Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society.
Newcastle-on-Tyne..North of England Institute of Mining and Mechanical Engineers.
North Staffordshire Naturalists' Field Club (Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage).
Norwich .....Geological Society, Museum.
Oxford .....Bodleian Library.
Radcliffe Library.
North Shields ....Public Free Library.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Warwick .....Natural History Society.
Watford, Herts ..Hertfordshire Natural History Society and Field Club, the Public Library, Watford.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee.....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton.....Mining Institute of Scotland.

III.—Ireland.

Dublin.....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast.....Natural History Society, The Museum.

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IV.—Australia.

Melbourne.....Geological Society of Australasia (Phœnix Chambers, Market Street).
Public Library of Victoria.

Sydney .....Free Public Library.
Royal Society of New South Wales, 37, Elizabeth Street.

V.—Canada.

Hamilton .....Hamilton Association.

Ottawa .....Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S., Director, Museum, Sussex Street, Ottawa).
M'Gill College (Principal, Sir J. W. Dawson, F.G.S.)
Editor of Canadian Mining Review.

Toronto .....Canadian Institute.

VI.—United States.

Boston, U.S......Free Library.

Chapel Hill, North Carolina, U.S. } The Elisha Mitchell Scientific Society.

Columbus, U.S.....Ohio, Geological Survey of (Professor Edward Orton, State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana, U.S. ....Department of Geology and Natural History.

Indianopolis, U.S...E. T. Cox, State Geologist.

Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.

New York, U.S....American Institute of Mining Engineers (R. W. Raymond, Box, 223, New York City).

New York .....American Museum of Natural History, Central Park.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.

Shenandoah, Pa. ..Editor of the Colliery Engineer.

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Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.
Wyoming, U.S. ..Historical and Geological Society.

VII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.
Brussels .....Société Royale Malacologique de Belgique.
Buenos Ayres ....Officiana Nacional de Commercie.
Calcutta .....Geological Survey of India.
Christiania .....Royal University of Norway.
Dresden .....Naturwissenschaftliche Gessellschaft Isis.
Halle, A.S......Verein fur Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.
Kieff, Russia ....La Société des Naturalistes.
Lausanne (*Suisse*)..Société Vaudoise des Sciences Naturelles.
Lille.....Société Géologique du Nord.
Naples .....Royal Society of Sciences, Bibliothèque de l'Université de Naples.
Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.
Rio de Janeiro ....Museo Nacional.
Rome .....Reale Accademia dei Lincei.
St. Petersburg ....Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.
Turin .....Académie Royale.

VIII.—Scientific Journals, &c.

Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review, 342, Strand, W.C.

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PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.

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LIST OF MEMBERS.

OCTOBER, 1888.

The Names of Honorary Members are printed in *Italics*.

*Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withins Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, 231, Ince Green Lane, Lower Ince, near Wigan.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1885	Barker, Israel, 319, Whit Lane, Pendleton.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool, *Member of Council.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1885	Bickerton, Charles W., Hazel Grove, near Stockport.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington. *Member of Council.*
1887	Boole, George, Rainford Colliery, near St. Helens.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.

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Year of Election.	
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester. *Vice-President.*
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 124, Rue Terre Neuve, Brussels.
1877	*Brongniart Charles*, F.E.S., 8, Rue Guy-de-la-Brosse, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, 33, Trafalgar Road, Birkdale, Southport.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, William, jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., 34, Belmont Street, Southport. *Member of Council.*
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester. *Vice-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1887	Chandley, Charles, Atherton, near Manchester.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1886	Clifford, William, Norton Woodseats, Sheffield.
1882	Cookson, Charles, King Street, Wigan.
1878	Cooke, Charles, Victoria Terrace, Station Street, Cannock, Staffordshire.
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*

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Year of Election.	
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton T. W.*, The Cedars, Methley, Leeds.
1865	Evans, Walter, Longsight, Oldham. *Member of Council.*
1880	Fairclough, William, Leigh, near Manchester.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1873	Garforth, W. E., Halesfield, Normanton.
1884	Garside, Sampson, Denton and Haughton Collieries, Denton.
1874	*Geikie, Archibald,* LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan. *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W., Stukeley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester.

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Year of Election.	
1879	Gregson, Edward, 11, Chapel Street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborne Hall, Newton-le-Willows.
1888	Grundy, James, H.M. Inspector of Mines, Gordon House, 343, Derby Street, Bolton.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines. Mons, Belgium.
1887	Hallas, Geo. H., Wigan and Whiston Coal Company, Ltd., Prescot.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace. Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, Wigan Coal and Iron Company, Wigan.
1885	Hindley, C. E., Polygon, Eccles.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Hon. Secretary.*
1884	Howat, Andrew, 25, Mill Street, Ancoats, Manchester.

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Year of Election.	
1887	Hughes, James, Astley and Tyldesley Coal and Salt Co., Limited, Tyldesley.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Hartford House, Werneth, near Manchester.
1887	James, J. Stanley, M.E., Leigh, Lancashire.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Westholme, Alsager, Cheshire.
1882	Johnson, William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1885	Kearsley, William, 115, Manchester Road, Tyldesley.
1879	*Kinahan, G. H.*, M.R.I.A., 132, Leinster Road, Rathmines, Dublin.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester. *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury, *President.*
1882	Knowles, Israel, Ince, Wigan.
1877	Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Arncliffe, Cheetham Hill.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Hon. Auditor.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1877	Lord, James, Hill House, Rochdale.

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Year of Election.	
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 6, De Grey Road, Leeds.
1884	Lyon, Edward, Ashton's Green Collieries, St. Helens, Lancashire.
1884	McAdoo, John, Colliery Manager, Hendreforgan Colliery, Ystalyfera, South Wales.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1873	*Martin, Joseph S.*, F.G.S., H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1887	Meadows, Christopher, Ellerbeck Collieries, Limited, near Adlington, Lancashire.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., F.G.S., Carlton Buildings, Cooper Street, Manchester. *Member of Council.*
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1887	Oldham, Thomas, Holmefield, Sale.
1888	Oliver, Samuel A., King Street, Wigan.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester, *Hon. Treasurer and Past-President.*
1874	*Owen, Sir Richard*, D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*

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Year of Election,	
1883	Peace, George Henry, Monton Grange, Eccles. *Member of Council.*
1877	Peace, Maskell W., F.G.S., Wigan.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester. *Member of Council.*
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1887	Platt, Samuel Sydney, Assoc.M.Inst.C.E., 14, King Street South, Rochdale.
1867	Radcliffe, James, F.G.S., Astley Deep Pit, Dukinfield; 108, King Street, Dukinfield. *Member of Council.*
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1887	Saint, William, H.M., Inspector of Mines, 24, George Street, Cheetham Hill. *Member of Council.*
1888	Scarborough, George Edward, Colliery Manager, New Town and Meadows Collieries, Wigan.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1887	Scott, Frederic W., Atlas Works, Reddish, near Stockport.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Madeley Coal & Iron Co., Limited, Madeley, near Newcastle, Staffordshire.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.

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Year of Election.	
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	Simpson, W. W., Winkley, near Whalley, Blackburn.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	*Smethurst, William, F.G.S.
1881	Smith John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, J. & P. Higson, 18, Booth Street, Manchester.
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bury.
	Stechert, G. E., 26, King William Street, Strand, London, W.C.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Swan Lane Brick and Coal Company, Hindley Green, near Wigan.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Sindsley House, Swinton, near Manchester.
1884	Toman, Daniel, Chamber Colliery, Oldham.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton. *Member of Council.*
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.

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Year of Election.	
1886	*Trafford, Sir Humphrey Francis De, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1887	Walkden, Richard, Colliery Manager, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, 11, King Street, Wigan.
1886	Wallwork, John, Clifton Moss Colliery, Clifton, Manchester.
1888	Walmesley, Oswald, 30, Connaught Square, London, W.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, High Lane, near Stockport.
1885	Ward, Thomas, Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale.
1878	Wells, Samuel B., General Manager Bengal Coal Co., Limited, Raniganj, India.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1884	Whitehead, John, Chorley, Lancashire.
1867	Wild, George, Albert Street, Bardsley, Ashton-under-Lyne. *Member of Council.*
1880	Williams, E. Leader, M.Inst.C.E., Manchester Ship Canal Co., Deansgate, Manchester.
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., Egerton Road, Fallowfield.
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Vice-President.*
1886	*Wood, Guy, 71, King Street, Manchester.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Member of Council.*

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, November 13th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, JOHN KNOWLES, Esq., M.Inst.C.E., in the Chair.

NEW MEMBER.

Dr. J. W. ASHWORTH, Thorn Bank, Heaton Moor, was balloted for and duly elected an Ordinary Member of the Society.

Mr. MARK STIRRUP (Hon. Sec.) stated that he had one or two announcements to make before the ordinary business was proceeded with. He had received a circular from the Committee on Science and Arts of the Franklin Institute, of the State of Pennsylvania, requesting that the members might be informed that the Committee was empowered to award, or to recommend the award of certain medals for meritorious discoveries and inventions tending to the progress of the Arts and Manufactures. Particulars as to these medals were given in the circular which was at the service of any member.

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A circular had also reached him from one of the committees of the British Association—the Committee appointed to arrange an Investigation of the Seasonal Variations of Temperature in Lakes, Rivers, and Estuaries in various parts of the United Kingdom. It was proposed to enrol volunteer observers immediately with a view to the commencement of observations in January, and the help of the Society or of its individual members was solicited to aid in carrying out this important inquiry.

ON THE COAL TRADE.

By Mr. JOHN KNOWLES, M.Inst.C.E., J.P.

It is now 15 years since I had the honour of being the President of the Manchester Geological Society—and it was at the time when the Society availed themselves of the offer made by the Literary and Philosophical Society to use their rooms, which I am sure has been appreciated by the Members.

During my term of office, which extended from November, 1871, to November, 1873, I read Papers on Mining and Fires in Mines—and I now propose to address you on the subject of Mining with regard to Commerce, although it may not be strictly in accordance with the objects of the Society, but is material to the Mining Section.

We are all aware that unless a mining undertaking is a success, it is not only a loss to the workers of the mines, but is also a serious loss to the country at large, and therefore any reliable statistics must be of service.

I have therefore made use of such information as I have, and hope it may be interesting, having prepared a Diagram of the Statistics of the Coal Trade.

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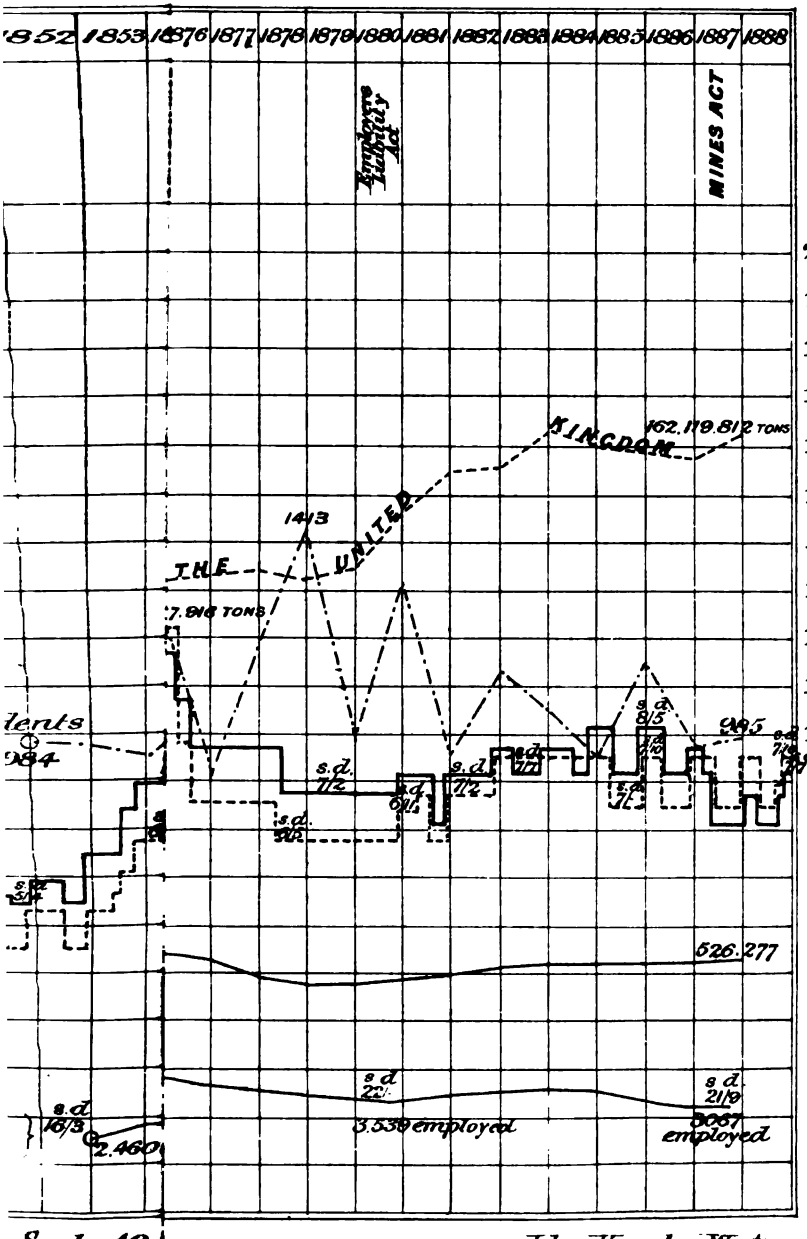
1821

Trans. Min. Geo. Soc. Part II. Vol. XX.
To illustrate Mr. John Knowles paper.



Scale 40

John Knowles, Westwood.
Nov. 13. 1888.

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Development of the Coalfield of Great Britain.

I have taken the statistical returns from 1857 to 1886, being 30 years—and find that in 1857, 65 million tons of coal were raised—at the end of 10 years, 101 million tons were raised, at the end of 20 years, 133 million tons were raised, and at the end of 30 years, 157 million tons were raised.

The increase for 10 years was at the rate of 4 per cent. on each preceding year, the increase for 20 years was at the rate of 3½ per cent. on each preceding year, and the increase for 30 years was at the rate of 3 per cent. on each preceding year.

In a conversation I had with the late Professor Jevons, I told him I considered the increase would be over a series of years at the rate of 3 per cent. on each preceding year, but he thought it would be at the rate of 3½ per cent., and so made his calculations. In his work on the coal question he estimated the quantity that would be raised in 1881 would be 166 millions of tons. The actual returns were 154 millions of tons, but have since been increased to 163 millions tons, and reduced to the get of 157 millions tons in 1886.

He estimated that the get in 1891 would be 234½ millions tons, which is not likely to occur.

With these statistics in view we have less cause of anxiety about the exhaustion of coal in this country than when the Coal Commission was appointed.

With regard to the use of coal very much greater economy has been effected, and now a larger amount of power and work is obtained from it, more particularly in the making of iron and steel than in any other industry.

There has been a great development in the washing and cleaning of coal and slack, so that it can be sent into the markets in a fit and clean state, thereby having less refuse to deal with at the various works.

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At a mill in this district, experiments have been made to show the difference between ordinary slack and washed slack; the following of which are the results :—

During one week the amount of good slack used was 78 tons, and the amount of cinder from it 11 tons 4 cwt. The amount of washed slack used during another week was 68 tons, and the amount of cinder 6 tons 10 cwt. In both cases the mill was running full time, and contained 66,864 spindles. Mechanical stoking is adopted.

With regard to transit of coal the question of quality is a great element, as the inferior kinds will not bear much charge on this head, therefore it is desirable that the less costly article should only be conveyed short distances.

Great facilities are, however, given to the transit of coal for shipment—and this applies to all the coal fields in the country. Only the best kinds of coals can be sent with economy to districts outside the coal fields.

With respect to prices of coal, this can only be dealt with in one case to give an idea of the changes which have taken place over a series of years—and I have taken as an example the price of engine coal delivered in Manchester from 1821 to 1888. It will be observed on reference to the diagram that there are various rises and falls from 1821, at which time it was 8s. 4d. per ton to July 1st, 1851, when the price was reduced to 5s. 4d. per ton. No doubt this low price was caused by the great depression in trade which occurred after the railway mania. Various rises and falls took place until 1871, when it had got up to 7s. 2d. per ton.

At this time we were experiencing the effects of the Franco-German war, and immediately a rise took place which culminated on October 1st, 1873, when the price rose to 17s. 2d. per ton. Since then various changes have taken place and the delivered price in Manchester is now 7s. 7d. per ton.

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With regard to wages this is an important element in the working of mines, which in this district have been for a many years regulated by the various changes in the price of coal at the pits—and as there is a large local consumption the workmen appreciate this method of arrangement.

On referring to the diagram it will be noticed that the lowest rate of wages was in 1850, at which time 4s. 3d. was paid to the collier for getting a load of coal equal to 3 tons 10 cwt.

Various changes took place after this until 1867, when the price paid was 8s. 6d. for the same quantity, when a rapid fall took place, and the price was reduced to 5s. 10d. in 1869.

The Franco-German War was in 1870, and in consequence of the cessation of labour in both countries, there was a very large demand for iron and coal, causing all prices to be advanced, the rate getting up to 12s. 2d. per load of 3 tons 10 cwt. After this there was again a rapid fall, and the price now paid is 7s. 10d. per load.

In the autumn of each year since 1852 I have had statistical returns from a series of collieries in this district of the number of men employed, the average rate of wages for each class of workmen, the amount of coal raised during the preceding 12 months, and the average wages per week for the whole set of men employed.

I find that when the return was first made the average wages for all, both men and boys, was 16s. 3d. per week, and then there were 2,460 workmen.

The highest rate of wages was in 1873, viz., 32s. per week, and 3,106 men were employed; and last year it was 21s. 9d. per week, and 3,067 men employed.

The higher rate now as compared with 1852 is accounted for by the fact that boys at 10 years of age were allowed to work in the mines, but now none are employed under 13 years of age.

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Since the passing of the Mines Regulation Act of 1872 there has been a great change in the employment of persons underground on account of the restriction of age—and, no doubt, this has encouraged a very extensive use of machinery in haulage, thereby avoiding the employment of boys under 13 years of age.

This is verified by the fact that in 1874 there were 428,611 employed underground and 110,218 employed above ground, making a total of 538,829. Whereas, in 1887, there were 428,540 employed underground, and 97,737 employed above ground, making a total of 526,277.

This shows a very material increase in the quantity of coal raised per person employed.

If we assume that the colliers work 250 days in each year, the calculation is that in 1874 232 tons of coal were got or 0·96 tons per man per day; and in 1887 the number of tons per man was 308 during the year, or 1·23 tons per man per day.

On referring to the diagram it will be observed that the line of changes in the number of persons employed is almost parallel with the line of wages, showing that high prices attract workmen to the collieries and low prices retard them.

With regard to fatal accidents there has been a considerable improvement in the fewer number as compared with the amount of coal raised, which is due to constant improvements being made in working the mines and the more extensive use of machinery for winding and haulage purposes, thereby enabling a large out-put to be made with fewer hands.

There is also the great element that practically boys are not much employed under 13 years of age, and therefore when they go into the pit are capable of doing more work.

The number of fatal accidents in 1857 was 1119, and 65,376,706 tons of coal were raised, making that 58,422

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tons were raised per fatal accident, and in 1887 there were 995 fatal accidents, and 162,119,812 tons of coal were raised, making that 162,924 tons were raised per fatal accident.

We have great advantages in this country in the encouragement which is given to Societies of Mining Engineers, of which this Society was one of the foremost, it being founded in 1837.

Members are encouraged to prepare papers on the various subjects with which they are conversant, and by mutual association have advanced the knowledge of mining to a great extent.

One of the finest and most useful set of transactions on the above subject may be found in connection with those of the North of England Institute of Mining and Mechanical Engineers.

There can be no doubt that the influence of these societies has been a great means of developing and improving the art of mining and increasing the safety of the workmen employed.

With regard to the development of the coal trade, a very great impetus was given to it in consequence of the rise in prices after the Franco-German war, and coalfields were opened out far in excess of the requirements of the trade. Also a large number of capitalists were brought into it, thereby interfering with the regular trader, and losing hundreds of thousands of pounds not only themselves, but others in the trade. At the same time rents and royalties were advanced, causing large outputs to be made to pay the stipulated rents.

We have certainly gone through a very anxious period, and I hope now that as the demand is nearing the supply, we may look forward to an improvement and more favourable times.

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FATAL ACCIDENTS.

			Tons Received in the United Kingdom.		Persons Employed Underground and Above ground.
1851	984	....	.....	....	....
1852	986	....	.....	....	....
1853	957	....	.....	....	....
1854	1,045	....	.....	....	....
1855	955	....	.....	....	....
1856	1,027	....	.....	....	....
1857	1,119	....	65,376,706	....	....
1858	931	....	66,107,603	....	....
1859	905	....	71,979,705	....	....
1860	1,109	....	84,042,698	....	....
1861	943	....	86,407,941	....	....
1862	1,133	....	81,638,338	....	....
1863	907	....	86,292,215	....	....
1864	867	....	92,787,873	....	....
1865	984	....	98,150,587	....	....
1866	1,484	....	101,754,294	....	....
1867	1,190	....	104,500,308	....	....
1868	1,011	....	103,141,057	....	....
1869	1,116	....	107,427,457	....	....
1870	991	....	110,431,192	....	...
1871	1,075	....	117,352,028	....	....
1872	1,060	....	123,497,316	....	....
1873	994	....	127,016,747	....	....
1874	1,056	....	125,067,916	....	538,829
1875	1,244	....	131,867,105	....	535,845
1876	933	....	133,344,766	....	514,532
1877	1,208	....	134,610,763	....	494,391
1878	1,413	....	132,607,866	....	475,329
1879	973	....	134,008,228	....	476,810
1880	1,318	....	146,818,622	....	484,933
1881	954	....	154,184,300	....	495,477
1882	1,126	....	156,499,977	....	503,487
1883	1,045	....	163,737,327	....	514,933
1884	942	....	160,757,779	....	520,376
1885	1,150	....	159,351,418	....	520,632
1886	953	....	157,518,482	....	519,970
1887	985	....	162,119,812	....	526,277

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Prices of Engine Coal Delivered in Manchester.

	s.	d.		s.	d.		s.	d.
1821	9	2	1848, Nov. ..	6	0	1869, Oct. ..	6	9
1823, March..	10	0	1849, June ..	5	9	1870, Sept. ..	7	2
1824, April ..	10	10	1850, January.	6	7	,, Nov. ..	8	0
,, Sept. ..	10	0	,, April ..	6	2	1872, January.	8	10
1826, June ..	9	2	,, June .	5	9	,, June ..	9	8
1827, March..	7	1	1851, January.	5	7	,, July ..	12	2
1829, March..	7	11	,, Feb. ..	5	6	,, Oct. ..	13	10
,, April ..	7	1	,, July ..	5	4	1873, Feb. ..	15	6
1830, Oct. ..	9	7	,, Dec. ..	5	9	,, Oct. .	17	2
1831, May ..	10	0	1852, June ..	5	4	1874, January.	15	6
,, June ..	9	7	,, Nov. ..	6	2	,, March ..	14	8
,, Oct. ..	8	9	1853, June ..	7	0	,, May ..	12	2
,, Dec. ..	7	11	,, Oct. ..	7	5	,, Aug. ..	10	6
1832, March..	7	6	1855, April ..	6	8	1875, July ..	10	1
,, May ..	7	1	1856, January.	6	3	,, Oct. ..	9	8
1833, Feb. ..	6	11	,, July ..	5	6	1876, April ..	8	10
,, ,, ..	6	8	1857, Oct. ..	5	11	,, Aug. ..	8	0
,, Dec. ..	7	6	1858, March ..	5	6	1878, June ..	7	2
1836, January	8	4	1859, January.	5	11	1880, Dec. ..	7	7
,, July ..	8	9	,, Dec. ..	6	9	1881, Aug. ..	6	9
,, Nov. ..	9	7	1860, March ..	7	7	,, Nov. ..	7	7
,, Dec. ..	10	5	,, Oct. ..	8	5	1882, Nov. ..	8	0
1837, April ..	9	7	1861, June ..	7	7	1883, April ..	7	7
1838, April ..	7	6	1862, Feb. ..	6	9	,, Nov. ..	8	0
1840, Feb. ..	7	1	1863, July ..	5	11	1884, July ..	7	7
,, July ..	6	8	,, Nov. ..	6	4	,, Oct. ..	8	5
1841, Feb. ..	7	6	,, Dec. ..	6	9	1885, May ..	7	7
,, July ..	7	1	1865, Oct. ..	7	7	,, Nov. ..	8	5
,, Oct. ..	6	8	,, Dec. ..	8	5	1886, June ..	7	7
1842, July ..	6	3	1866, Oct. ..	9	3	,, Dec. ..	8	0
1843, January	6	0	,, Nov. ..	10	1	1887, Feb. ..	7	7
,, Oct. ..	6	10	1867, Aug. ..	9	3	,, May ..	6	9
1844, January	7	3	1868, January.	8	5	1888, January.	7	2
1845, March..	7	8	,, June ..	7	7	,, April ..	6	9
1847, June ..	6	10	,, Dec. ..	6	9	,, Oct. ..	7	2
1848, May ..	6	6	1869, April ..	6	4	,, Nov. ..	7	7
,, July ..	6	3	,, June ..	5	11			

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PRICES PER LOAD OF 3 TONS 10 CWT. PAID TO COLLIER.

Date.	Price. s.	d.
1850.—January	4	3
,, —November	4	7
,, —December	4	11
1851.—May	4	7
,, —November	5	3
1852.—June	4	7
,, —October	5	3
1853.—May	5	7
,, —June	5	11
,, —October	6	5
1855.—April	5	9
1857.—May	5	1
,, —October	5	9
1859.—January	6	1
,, —December	6	5
1860.—March	6	8
,, —September	7	2
1861.—June	6	8
1862.—February	6	0
1863.—July	5	4
,, —November	6	0
,, —December	6	6
1865.—October	7	0
,, —December	7	4
1866.—April	7	10
,, —November	8	6
1867.—April	7	10
1868.—June	6	10
1869.—June	5	10
1870.—February	6	6
1871.—September	7	2
,, —November	7	6
1872.—January	7	10
,, —June	8	6
,, —July	9	6
,, —December	10	6
1873.—March	11	2
,, —October	12	2
1874.—May	10	2
1876.—April	8	2
,, —August	7	2
1878.—June	6	5
1880.—December	6	11
1881.—April	7	2
,, —August	6	5
,, —November	7	2
1882.—November	7	10
1885.—May	7	0
,, —November	7	10
1886.—June	7	0
,, —December	7	10
1887.—May	7	0
1888.—January	7	10
,, —April	7	0
,, —October	7	5
,, —November	7	10

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	Average Weekly Wage Paid to each Workperson.		Number Employed.
	s.	d.	
1852.—October 1st	16	3	2340
1853.— ,, ...	18	7	2697
1854.— ,, ...	18	3	2814
1855.— ,, ...	16	8	2650
1856.— ,, ...	16	7	2843
1857.— ,, ...	16	9	2747
1858.— ,, ...	16	7	2846
1859.— ,, ...	17	8	2825
1860.— ,, ...	20	1	3186
1861.— ,, ...	18	9	3223
1862.— ,, ...	15	9	2963
1863.— ,, ...	16	6	2607
1864.— ,, ...	18	7	2745
1865.— ,, ...	18	11	2897
1866.— ,, ...	21	9	3063
1867.— ,, ...	23	3	3299
1868.— ,, ...	21	0	3212
1869.— ,, ...	19	7	2915
1870.— ,, ...	20	10	3151
1871.— ,, ...	23	2	2808
1872.— ,, ...	28	0	3047
1873.— ,, ...	32	0	3106
1874.— ,, ...	29	1	3185
1875.— ,, ...	29	2	3400
1876.— ,, ...	25	2	3197
1877.— ,, ...	25	1	3148
1878.— ,, ...	23	8	3184
1879.— ,, ...	22	9	3553
1880.— ,, ...	22	2	3539
1881.— ,, ...	21	11	3680
1882.— ,, ...	23	6	3615
1883.— ,, ...	24	4	3442
1884.— ,, ...	23	10	3586
1885.— ,, ...	22	4	3385
1886.— ,, ...	21	4	3391
1887.— ,, ...	21	9	3067

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Mr. DICKINSON moved and Mr. PILKINGTON seconded a vote of thanks to the President for his very valuable and instructive address. Carried unanimously.

The PRESIDENT, in replying, said it was a great pleasure to him to be able to prepare this diagram. He began in a small way, collecting statistics, many years ago, and had added to them from time to time. He thought that by bringing the facts before this Society they might be useful hereafter, as a record of the state of the coal trade over a given period. Others, he said, may carry the statistics forward by making similar observations and collecting similar facts.

The PRESIDENT, referring to the diagram, described somewhat more in detail the prominent points in his paper. The diagram, he said, showed the prices of coal delivered in Manchester, and one curious feature was that there was a continual fall to a point they all remembered very well—the time of the Great Exhibition. Then a rise took place, which continued to the time of the Crimean War, which was succeeded by another fall during the Indian War. After the Exhibition of 1862 there was a great rise, and then a fall, which was not recovered before the Franco-German War. This war brought about a great rise, and prices reached a high figure; then there was a sudden drop, and prices had since been tolerably even. Generally speaking, fatal accidents increased in number with the increase of prices, but it was curious to note that during the high prices of 1872 the accidents were fewer. As to the rate of wages, beginning with 1851, the average was 16s. 3d. per week per person—man and boy—and they could trace on the diagram a gradual rise till it reached the highest point, namely, 32s. per week; after which there was a fall to 21s. 9d.

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In reply to Mr. Burrows,

The PRESIDENT said the rate per load of 3 tons 10 cwt. paid to miners rose from 4s. 3d. till, in 1873, it reached the high figure of 12s. 2d. After that the diagram exhibited rates of wages varying with the prices obtained for coal.

Mr. DICKINSON: This table shows that, following some of the principal Mining Acts, the prices of coal have gone up. This was so, soon after the Act of 1872, as also after the passing of the Inspection of Mines Act in 1850. But the rise after the more recent Mining Act of 1887 has not yet taken place. We may expect, according to the evidence before us, that it will follow.

ON THE CLAY SLATES AND PHYLLITES OF THE SOUTH OF THE ISLE OF MAN; AND A SECTION OF THE FOXDALE MINE, ISLE OF MAN.

By PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., &c.

Professor DAWKINS said:—Mr. President—I thought I might be allowed to put before you this afternoon the first instalment of my six-inch geological map of the Isle of Man. The two points to which I would particularly direct attention this afternoon are—first of all, the clayslates and the phyllites which compose the main mass of the island; and secondly, the Foxdale granite and the Foxdale mine.

The clayslates pass insensibly into the phyllites in the island, by the development of mica in the planes of deposit, and in the south of the island the latter predominate, being grey, black, or sometimes red. In the cliff sections they are seen to be highly contorted and greatly faulted. They are interbedded with quartzites and traversed by numerous veins of white quartz. It is along the junction of these

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hard and intractable materials with the more yielding slaty series that the maximum development of mica has taken place, due to the mechanical movement during contortion having locally developed heat along the planes of friction between the two. These planes are frequently covered with a continuous glittering film of mica.

The enormous strain to which the phyllites have been subjected is shown by the micro-sections, in which they are seen to be traversed by a series of parallel or nearly parallel cleavages. Each of these is a small fault on each side of which the layers of mica have been displaced. In the quartzite in the harbour of Port St. Mary the same structure is to be seen—"the strain-slip cleavage" of Professor Bonney—and it is visible in a series of ripple-like steps which traverse the surface of the stone in a direction obliquely to the true ripple-marked surface.

The phyllites are abruptly cut off to the south by the great fault traversing Port St. Mary, and passing from the pier in the harbour to the north-east to Athol Bridge. By the Port St. Mary fault the carboniferous limestone has been faulted along the line of strike. The true junction between the two strata is, however, to be seen in the valleys in the neighbourhood of Balla salla, and in the peninsula of Langness, where a red conglomerate of quartzite rests on the eroded edges of the phyllite series, and dips conformably under the carboniferous limestone. It marks the shore-line of the carboniferous sea, and was gradually being accumulated while the area was sinking. The pebbles in the conglomerate are derived from the rocks of the district, and the red colour of the quartzite is merely due to subsequent peroxidization of the blue protoxidated rock from which the pebbles were derived. In the ravine of the Awin Ruy the quartzite rocks are no less than 632 feet in thickness, and

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are in some places coloured red. These quartzites, or their equivalents now concealed by the sea to the east, and the newer rocks, may, perhaps, have contributed to the pebbles of the Triassic Sandstones, and must be taken into account in examining into the history of the Triassic shingle beaches in Lancashire and Staffordshire.

In walking northwards from Ballasalla to Foxdale, the ice-borne granite blocks which strew the surface and are dotted along the hedges become thicker and larger, until the granite area of Foxdale is reached, from which they were derived.

The granite is a boss thrust up through the phyllites, which are very much altered at the line of junction, the plates of mica being enlarged, and various obscure minerals being developed in the shape of needles, and granular aggregations. The plates of mica also in the micro-section of the rock close to the junction have been crushed and distorted by the enormous pressure to which they have been subjected.

The granite in a micro section is seen to consist of orthoclase and plagio-clase crystals, biotite and quartz. In the neighbourhood of the Foxdale mine it is much decomposed, and a sufficient amount of an obscure green mineral is present to give its tint to the rock.

The principal lode* at Foxdale traverses the phyllites and the granite, and is a rake vein running east and west with a hade of 1 in 3 to south. It has been worked to a depth of 1512 feet. In the neighbourhood of the new shaft it plunges into the phyllites at the surface, and passes into the granite at a depth of 300 feet.

*I have to thank Captain Kitto, the manager of the Foxdale mine for much of this information.

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The lode is about 25 to 35 feet thick, and besides the rich combs of lead and silver-lead ore, and sulphide of barium, and carbonate of iron, it contains two lines of angular granite blocks, which apparently had dropped into it when it was an open fissure, and probably at two distinct and successive times, after two distinct and successive widenings. Another point of considerable interest is presented by the large amount of carbonic acid which is given off at the bottom of the workings. It is likely that the presence of this destructive chemical agent has caused the peculiar alteration in the granite, which has been noticed above, in the neighbourhood of the vein.

Mr. DICKINSON asked Professor Dawkins if he had formed any conclusion as to the throw of the Port St. Mary fault.

Professor DAWKINS: I am sorry I cannot give you any information upon that point because I do not know the thickness of the limestone. The limestone is so crumpled and so difficult to make out, that I would not like to take any responsibility in answering the question.

Mr. PLATT remarked upon the differences that seemed to exist between the Isle of Man carboniferous limestone and that of Derbyshire; fossils being found in the one that did not seem to occur in the other. Beds or partings of shale were also much more frequent in the former.

Mr. STIRRUP said he had the privilege last year of accompanying a party of the members of the British Association which visited the Isle of Man on the invitation of the Isle of Man Natural History and Antiquarian Society. On that occasion they had the benefit of Professor Dawkins' guidance to a portion of the district referred to. They were then able to see, however cursorily, how much there was in the rocks of the island to interest the geologist. Within easy reach of Castletown may be seen the conglomerates referred to and many

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interesting varieties of volcanic rocks of carboniferous age and trap dykes in the vicinity of the carboniferous limestone. No authoritative geological map of the island existed, and he was therefore glad to find that Professor Dawkins had made a beginning, to supply the deficiency. With regard to the geological age of the quartzites and phyllites to which their attention had been drawn, he thought, from their appearance and crystalline condition, there was a possibility that they might be older than the Silurian, for as yet there was no fossiliferous evidence to assist in the determination of their age. These ancient crystalline rocks were now being closely examined by the aid of the microscope, and it was to be hoped, that by this means additional light might be thrown on the question of their geological antiquity. Mr. Stirrup also referred to his visit to the Foxdale Lead Mine, when he was one of a small party of three or four invited by Captain Kitto to visit the underground working of the mine, the late lamented Professor Carvill Lewis, of Philadelphia, being one. He well remembered the interesting discussion that took place, deep in the bowels of the earth, between himself and the Professor, as to the origin of mineral veins and their mode of infilling, a subject aptly illustrated by the lodes of lead incased in their granite walls by which they were surrounded.

Professor Boyd-Dawkins, in reply, said—With regard to the age of these rocks I am afraid I must suspend my judgment. I am in the same unfortunate position, as far as that goes, as my friend Mr. Stirrup. I really do not know what age they are. It is certainly not later than the Lower Silurian, and it may be much older. But I have no doubt that when the island is surveyed geologically on the six-inch scale we shall arrive at a true conclusion as to the place of the phyllites and clay slates in the geological scale.

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Specimens of the various rocks to which reference had been made were exhibited by Professor Dawkins, and at the close of the meeting a series of rock sections in illustration of the paper were shown under the microscope.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, December 11th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, JOHN KNOWLES, Esq., M.Inst.C.E., in the Chair.

NEW MEMBER.

Mr. DONALD MUNRO, mining engineer, Ashton Moss Colliery, Ashton-under-Lyne, was balloted for and unanielected an Ordinary Member of the Society.

MINERS' ELECTRIC SAFETY LAMPS.

The Hon. Secretary reported that, in the unavoidable absence of Mr. John Higson, F.G.S., who had promised to exhibit the lamp and read a paper upon it, Mr. O. R. Swete had kindly undertaken the duty at Mr. Higson's request.

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A NEW MINERS' ELECTRIC SAFETY LAMP.

By Mr. Oswald Ricketts Swete,

Associate of the Society of Telegraph Engineers and Electricians.

At the invitation of Mr. John Higson, who, I regret to say, is unable to appear, through circumstances over which he has no control, I have much pleasure in appearing before you here to-day, in order to give some information concerning the lamp invented and manufactured by the Mining and General Electric Lamp Company, Limited, of 43, Colman Street, London, E.C.

Before, however, going into the details of this new Electric Miner's Lamp, I think it interesting to give you some account of the work that has been done by other inventors of electric mining lamps.

No doubt many of you here have seen and practically tested various kinds of electric mining lamps, and therefore have your own opinions about them; but I think it is generally acknowledged that to obtain a perfect safety lamp it must by necessity be an electric one; since the only light requiring no oxygen to support it, combustion not taking place, is that afforded by the incandescent or electric glow lamp.

The inventors of these lamps until recently confined their efforts to the use of primary batteries as the scource of energy for supplying the light to their lamps; but, I may say, that it is almost impossible to produce a good and cheap electric mining lamp by this means. With primary batteries many difficulties are at once placed in your path, such as,—consumption and renewal of the positive element zinc, continued cleaning and scraping, together with subsequent amalgamation by means of mercury, of the positive element;

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in some cases porous pots are used, which insert great internal resistance, and the continual recurring nuisance of fracture; low electromotive force entailing the use of many cells, and therefore great weight in order to obtain the necessary amount of light; the use of very corrosive and dangerous chemicals as deoxidising agents, such as bichromate of potash and sulphuric acid, bichromate of soda and nitric acid, bisulphate of mercury, &c.; gas escaped from the battery during discharge of the electric current through the lamp, thus entirely preventing the cover being fixed down liquid tight; difficulty of keeping connections and contacts clean and free from corrosion; great expense incurred thereby; deposition of deoxidants on positive element; and very high cost of maintenance and repairs.

Now let us consider what could be done with secondary batteries. A few years back they were decidedly behind primary batteries, in the Planté type the active material on the plates was about $\frac{1}{40}$ the total weight of the elements, thereby making a two-cell miner's lamp weigh about 17 pounds.

In the Faure type, more recently brought out, the relation between the dead weight of support and the active material was two to one, making a two-cell miner's lamp probably weigh nine or ten pounds. In 1885, however, a great advance in secondary batteries was made by Mr. D. G. Fitzgerald, inasmuch as he did away with the dead weight of support altogether, and obtained a dense, hard, and highly conductive plate of solid peroxide of lead for his negative element, which he termed lithanode, and containing no support whatever, but wholly consisting of active material, and a two-cell miner's lamp constructed with this kind of element would weigh from four to five pounds.

The total weight of secondary batteries per horse-power-hour capacity is as follows:—

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	lbs. weight.
Planté	396
Faure	198
E.P.S. (L type)	133
„ (S type)	135
Lithanode (old form)	76
„ (latest form)	70

or 1-5th the weight of a Planté battery of the same capacity.

This brings home to us the enormous advantage gained by the use of this new material for secondary batteries, which no other substance yet known can compete with.

Thus it is the very thing suitable for solving the problem of electric safety lamps. But not only is it applicable to that, but has a far more extensive field of action, such as lighting towns by central stations, houses, railway cars, trams, omnibuses, and cabs, police and watch lanterns, lamps for powder magazines, and for all purposes where portability, efficiency, and economy are the *sine qua non.*

But it is not my purpose to go into those matters to-day.

This small weight, therefore, brings lithanode batteries for mining purposes to the front, other things being equal; but they are more than equal, for besides the light weight of this new type of secondary battery, no renewal of elements is required, nor of the electrolyte (dilute sulphuric acid); no gases evolved on discharging the current through the lamp, therefore no necessity for valves or other complicated arrangements to emit the gas without the liquid. It is this last radical improvement in secondary batteries that is the mainstay of the mining lamp placed before you to-day. Most of you remember, I dare say, the lamp I had the pleasure of showing to you last January at your meeting at Wigan. It was then in its experimental stage, and known in the Wigan district as the "Sun" lamp, but which title, however, the Company for cogent reasons have aban-

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doned. This is the outcome of that lamp and the numerous tests which have been undertaken in connection with it.

The electromotive force is four volts, it consists of two cells, containing one positive and negative element and bolted together in each cell. Its weight at present is but five pounds which can be considerably reduced later on. Its candle power is that of one standard candle. Burns for twelve hours with one charge from a dynamo machine of five hours.

You will observe that the glow lamp can be placed wherever best suits the requirements of the colliery owner, viz., on top, bottom, or side, or may be detached altogether from the battery, as in the case of this small railway reading lamp, ready to be affixed to the coat or cap.

The battery case is made of birch of a peculiar section, occupying as small a space as is possible, exceedingly strong, and rendered waterproof and acid proof by a patented process.

There is another novelty in the glass protector covering the incandescent glow lamp. This consists of toughened or chilled glass, which has great strength, but when broken, instead of cracking or breaking into large fragments, flies to very small particles; a lever pressing against the inside of this glass cover, would thereby instantly fall forward if the cover were broken, and this at once cuts off the electric current, before the blow that breaks the cover could have time to reach the incandescent lamp; thus rendering it absolutely impossible for an explosion to take place from contact of a red-hot filament with a mixture of air and fire-damp.

This cover is capable of being locked with a lead plug, and the miners can be given to understand that, in the event of some untoward accident they were entombed within the workings, by unpicking the lead plug with a pocket knife,

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and removing the glass cover, the light could be saved up until assistance arrived, which is impossible with any existing oil lamp. The lid is screwed down tight by means of a steel lever and lock nut and sealed with a lead plug. There is no switch whatever, the action of putting on the cover lights the lamp, and the miner cannot put it out except by breaking the sealed plugs.

By undoing four ebonite nuts inside the battery, the whole of the elements can be instantly withdrawn, for the purpose of repair, &c.

The plates, so far, have been tested to 2½ years; and are practically indestructible by wear and tear. The total weight of the two sets of elements is 1lb. 2ozs.

The lamp can be turned upside down without detriment, and if turned at an angle will not go out, like some oil lamps, thereby saving the "hewer" many a mile's walk.

Now a word as to cost and maintenance. Suppose you want to take 1,000 lamps, what will it cost you?

1,000 lamps at 20s. equals £1,000; a 5-unit dynamo machine equals £75; instruments, wires, &c. equals £15; total, £1,090.

Maintenance, per annum. Interest on £1,090 at 5 per cent. equals £54 10s.; depreciation on £1,090 at 10 per cent. equals £109; current, 7,800 units at 7d. equals £227 10s.; wages, two men at £52 and 3 boys at £19 10s. equals £162 10s.; incidental expenses, equals £10 10s.; total £564, which is equal to 2½d. per lamp per week, burning twelve hours per day, six days per week.

Now I have charged the current in the maintenance account at 7d. per Board of Trade unit, which is the London price, where coals are at 17s. to 20s. per ton and rent and wages are far higher than here; therefore, you will readily perceive that I am well within the mark when I say that 2½d. per lamp will cover the cost of maintenance per

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week. No oil lamp, candles, or primary battery can compete with this, and the saving effected on maintenance alone will soon pay the extra cost of lamps; but beyond everything it is absolutely safe, and a good light, better than that at present obtained from oil lamps.

I may add in conclusion, that this lamp has now been tested for a period extending over nine months in various collieries in the north of England, including the Wigan Coal and Iron Company, Limited; Messrs. Pearson and Knowles, Limited; Dukinfield and Astley Coal Company; Shireoaks Colliery, Limited; Messrs. John Brown and Co.'s Aldwarke Collieries, and the Weardale Iron and Coal Company, Limited; and in all mines has met with a flattering reception.

A vote of thanks to Mr. Swete having been unanimously passed, that gentleman briefly responded and gave some further technical information with regard to the construction of the lamp, which he exhibited.

In reply to a question as to whether it required a skilled man to charge the lamps,

Mr. SWETE said that no skilled attendant was needed. Any ordinary mechanic, or even lamp-room man, would be able to do all that was necessary.

Mr. HERBERT FLETCHER: Mr. Swete says that "no oil lamp, candles, or primary battery can compete with this"; does he mean in cost? or in what the Royal Commission requires as essential to the miner's safety, namely, a handy and good light? Can this lamp be used in a miner's working place with the same facility as a candle?

Mr. SWETE: When I said that no oil lamp could compete with this, I meant in cost only. It has not been tried long enough to enable us to say whether or not it is as handy as an ordinary miner's lamp.

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Mr. FLETCHER: The cost is a commercial consideration.

Mr. SWETE: Yes, entirely.

Mr. FLETCHER: I should remark on that, that as a body representing mining engineers, it is a consideration which should with us be very secondary to that of safety; and, although a saving in the cost of lighting might be effected by the use of electricity or oil lamps, yet, if in so doing the men were deprived of either of the qualifications of what the Royal Commission declared, after seven years' careful deliberation, to be a most important factor in the safety of the underground miner, a "good and handy light," the electric lamp must be received with caution when it is prescribed as a substitute for the candle, which I take to be what the Royal Commission meant, when they spoke of a "good and handy light." We must remember not to lose sight of the handiness in our search after the intensity.

Mr. SWETE: Well, I do not know that there can be any objection to this lamp on the score of handiness. You can examine the roof with it, turn it upside down, and knock it over without causing it to go out, and, as to the Royal Commission, it has, I may add, been most favourably received by Sir Frederick Abel, as a safe lamp. When I spoke of other lamps not been able to compete with it, I meant in cost of maintenance. An oil lamp, I believe, costs from 4d. to 6d. to keep it trimmed and to keep the gauzes clean. There is nothing of the sort required in this electric lamp, 2½d. will cover everything.

Mr. FLETCHER: I think Mr. Swete is right in saying that the light is better than that of an oil lamp. I myself have tried them, and also Mr. Burrows, and after he has spoken I shall be glad to give my own experience; but in giving us his experience gained with this lamp, Mr. Swete is looking at it from the point of view of the overman who

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carries a lamp for examination, and the advantages of the lamp for that purpose are very great. It is a lamp for the use of the overman, for whom a good light is especially important, in order that he may examine the condition of the places into which he cannot enter. It is most important to be able to see the condition of the roof from a considerable distance, and where access is impossible, and especially is a good light necessary where attention has to be paid to the building of walls and goaf stowing in long wall working, &c. But when the Royal Commission mentioned "a good and handy light," they were not thinking of the overmen, but of the workman,—possibly—on his knees, in a steep mine, who has to fix his light on a prop, and therefore often to fix a prop—perhaps a heavy one,—before he can move his light. A candle he can fix in position where an oil or an electric lamp which has to be suspended, and is heavy, cannot be placed. If Mr. Swete had had the experience of an underground collier, he would not have claimed to rival the candle in its handiness for the coal-getter, whose interest we, as engineers, cannot neglect. Our first business is to consider the safety of the men working under our direction, and then only the improvement of the means by which coal, upon which all our industries depend, can be extracted from the earth. These are the considerations which we need to place before the interests of promoters of electrical appliances, or even of capitalists, when they seek to substitute any light by force, for the superior advantages of the candle, in order to save themselves from the consequences of failing to supply sufficient ventilation,—consequences, which must weigh on their sense of responsibility more than those from falls of roof and sides.

Mr. Swete: Although I cannot claim to have had any experience of mining, I may say that these lamps have been

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in use by practical miners in the North of England with most satisfactory results. A dozen or more lamps were at one colliery taken underground every day for a fortnight, and at the end of that time the men were asked to give their experience, they all said that they preferred the electric lamp to the Marsaut for handiness; it did not go out if knocked over; it could be placed back from the face, and once set down there was no need to move it again during a whole day. It needed no emptying, and above all, they knew that they were absolutely safe with it. I have not been down a pit where naked candles are used, and cannot speak of the merits of that system of lighting, but I believe the practice is to stick the stump of the candle in a piece of clay as a holder. That is very handy, no doubt, but in my judgment it is very dangerous. It is also easily knocked over and the light extinguished. Our electric lamp cannot be extinguished by any simple accident of that kind, the glass must first be broken, and the glass being very strong is not easily broken.

In reply to questions, Mr. SWETE replied that a five unit machine, costing £75, would be sufficient to charge 1000 lamps. It required a ten-horse power engine to work it. The lamps were connected together in series. He believed that two men and three boys would be quite capable of looking after 1000 lamps. They could connect them up ready for charging in half an hour.

A member enquired if there was any risk from over-charging the lamps.

Mr. SWETE said, none whatever. When the lamps were fully charged volumes of hydrogen gas were given off. There was no risk of deterioration of the elements, as in some other batteries. They could tell by the fumes of hydrogen that were given off, and by the deep plum colour of the positive plate, when the lamps were fully charged.

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In answer to Mr. Bramall,

Mr. SWETE said that 1,000 hours was a fair average life of an incandescent lamp.

A MEMBER: The electric lamp gives the miner no indication of the presence of gas. He would never know when he got into an atmosphere of carbonic acid, for instance, to detect which an ordinary safety lamp would still be necessary.

Mr. SWETE: That is the only objection that can be urged, and it is the only one we have not been able to get over. But in a month or two we shall, I believe, be able to give you a perfect safety lamp with fire-damp detector and also carbonic acid gas detector. Experiments which have been perfectly satisfactory have been made in this direction.

Mr. FLETCHER; Do the carbons break at intervals?

Mr. SWETE: We have never known one to break unless it had served the full average term. A register is kept of all the incandescent lamps used and the number of hours run. The lamps are those manufactured by Pitkins.

Mr. FLETCHER: We were troubled with the carbons continually breaking.

Mr. SWETE: Pitkins' lamp is furnished with a resistance to check the first flush of the electro-motive force, as if the switch is turned full on you get more light than is really needed, and the carbon filament is deteriorated and rendered liable to be broken. But with our lamp, we have an automatic resistance which, as I said, takes off the first flush of the electro-motive force; consequently, the lamps last the whole life-time of 1,000 hours. We buy all our lamps from Pitkin, and with this arrangement, we have no trouble with them.

Mr. FLETCHER: My own impression in using them was that the candle made a fool of the lamp—to put it in common parlance—and the Pitkin lamp made a fool of the

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candle, that is, in the intensity alone of the light it gave. It was beautiful, and the men would have used the electric in preference to oil lamps if they could have depended on the carbons lasting. But they were liable to such constant break-downs.

Mr. SWETE: We do not find it so, on account, as I explained, of the employment of the automatic resistance. Without that we should be troubled in the same way.

Mr. BRAMALL pointed out that if the cost of each incandescent lamp was 1s. 6d. or 2s. for renewal, the cost of maintenance would amount to more than the sum mentioned by Mr. Swete, namely, 2½d. per week each. The renewal of the lamp alone would amount to more than that. In the collieries in which he was interested, the incandescent lamps were extensively used for lighting purposes, and his experience was that the carbons did not last nearly so long as 1000 hours. The lamps used are the Edison-Swan lamps, and are 60, 75, and 100 volts at the respective installations.

Mr. BURROWS said that at the Atherton Collieries the Edison-Swan lamps had been in use since July 8th, 1887, and only two had been changed during that period. They worked all day and part of the night, two only had been broken, and these by a blow.

Mr. SWETE said, that much depended upon the steadiness of the engine.

Mr. BURROWS said, they had employed a few of the Edison-Swan lamps on the surface, which failed entirely, he believed on account of the damp penetrating the plaster of Paris.

Mr. FLETCHER: Are you speaking of portable or of fixed lamps?

Mr. BURROWS: Fixed lamps.

Mr. SWETE, in reply to a member, said he believed it was intended to adhere to the offer made at the last Wigan

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meeting to maintain the lamps for 3d. per week per lamp. He might state that one of the lamps exhibited had run for 22 hours, although it was supposed to be only a 12-hours' lamp. The plates gave out electrical energy to the very last grain, every grain of the plate was active material.

Mr. FLETCHER: These lamps for colliers' use, I understand, you will maintain for 3d. per week.

Mr. SWETE: Yes.

Mr. FLETCHER: Considering that the lamps have not yet been brought into practical use I certainly think the offer a bold one.

Mr. SWETE: The tests to which the lamps have been subjected have been sufficiently long to be deemed practical.

The PRESIDENT: I think we ought to be extremely obliged to Mr. Swete for coming here to exhibit and explain this lamp. It will be for those of us who are interested in collieries to see how far it can be adopted.

Mr. J. S. BURROWS then read the following communication on his experience in working the Edison-Swan lamp:—

NOTES ON WORKING WITH THE EDISON SWAN LAMP.

By Mr. J. S. BURROWS.

The following remarks are simply the result of the writer's experience with the Edison Swan Portable Electric Mining Lamp, and are not intended as a criticism of or comparison with any other lamp.

My observations on the Edison Swan Lamp may be divided into three parts, viz.:—

1. The good qualities of the lamp.
2. The bad qualities of the lamp.
3. Some rough indications of what is required to adapt the lamp for general use.

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1. As to its Good Qualities.—The Electric Lamp is such an advance on anything in the way of an oil lamp, both as to the good and steady light given, and the comfort and ease with which the roof, &c., can be thoroughly examined that, though I cannot perhaps say much that is new, I feel bound to do anything in my power to improve the lamp, or induce others to try it. To give a very rough idea of its lighting power, the lamp under notice is better for seeing objects straight before one, than four large Marsaut lamps with flat wicks, newly trimmed and bright, besides which, as everyone knows, the light is of a very different quality, enabling small objects to be discerned more clearly than by the comparatively dull glow of the best oil lamp. The writer has been enabled to thoroughly examine the roof 14 feet above the floor, and to distinguish the slightest unevenness or break, simply by holding the lamp above the head, and could apparently have seen to a much greater height had there been an opportunity. It is a common thing when leaving a collier's place to hear him say he cannot see anything now the Electric lamp has gone, although he still has two or three Marsauts hanging up in his place; and I believe several colliers would buy Electric lamps (though provided with oil lamps) were the price more reasonable. When in perfect order, the lamp gives a good light at the end of 10 hours, can be turned upside down, or knocked over with impunity, and dust, heat, or draught make no difference in its good burning qualities. If such a lamp were adopted in our collieries, accidents would diminish very rapidly, explosions could hardly occur, unless the gas were fired by a shot, and men would not be found working under dangerous roof, or in insufficiently propped and spragged places, when the full extent of the danger was apparent, without having to reach a lamp, and make a special examination, as must be done with the present lamps.

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2. As to the Bad Qualities of the Lamp.—First and worst is the enormous price charged for it. Three guineas retail and two guineas wholesale per lamp, seems a fabulous sum for a lamp which is very simple in construction and which contains no expensive parts. The construction of the lamp is faulty, considerable time must be wasted in getting the composition case out of the wooden box to replace even a wire destroyed by the leakage of acid—a common occurence, and time is lost again in replacing the case and making the top acid proof.

The switch projecting from the back or side of the box is very liable to get damaged by a blow against one's legs, or against a prop or tub. The weight is also an objection, 7 or 8 lbs. is a good deal to carry, though I do not attach so much importance to this (as there is a broad leather strap to carry it by, and the light is not affected by the position in which the lamp is held,) except perhaps for drawers or waggoners. Even in their case there might be some arrangement for attaching the lamp to the tub by a hook and spring to lesson the vibration; or, in many cross-gate roads in long-wall working, each drawer might hang his lamp up at the bottom of his jig brow, and the level would then be sufficiently illuminated for drawing purposes. Colliers would only feel the weight in carring their lamps to and from their working places, as, once there, the lamp could be hung up in such a position, that it would seldom require to be moved.

3. What is Required.—The oak cases should be done away with as the acid destroys them, and, say, a round case of papier-maché or similar material substituted; the lid or top should be made to open readily, so that defective plates could be replaced as easily as the wicks in our present lamps. All connecting wires should be led outside the external case under an easily removable guard. The switch

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might be so arranged that when the lamp was given out, a lead or other rivet locked in the usual way would make the necessary connection and prevent any tampering with the lamp. The first cost must be largely reduced and the battery plates and other parts sold wholesale, so that an intelligent lampman could put them in when required.

The writer feels that these remarks are incomplete without a statement of the length of time the lamps go without repairs, and the cost of such repairs. These particulars cannot be given because the lamps in every case have had to go to the makers in Manchester for repairs, and we could not always tell what had gone wrong. The acid getting between the oak box and the composition case holding the battery corrodes the wires supplying the incandescent lamp, which corrosion has often been the cause of failure, but, were the lamps so made that these wires could be easily got at, such small repairs would be done by the lampman and nothing would be heard of the matter.

In conclusion, there is no fault to find with the behaviour of the Edison Swan Lamp when in good order, and it only rests with the makers to adopt the tradesmen's motto, "small profits and quick returns," at the same time simplifying the construction, and supplying all parts needed for repairs, as the oil lamp makers do. When this is done, the Electric lamp will soon take its proper place, as *the* lamp for underground work.

A vote of thanks to Mr. Burrows was unanimously passed.

The PRESIDENT observed that an essential requisite in a mine was undoubtedly a good light, and it must not only be good, but safe. If, as Mr. Swete had stated, a lamp could be brought out which would indicate the presence of fire damp—for which purpose the incandescent lamp now ex-

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hibited was useless—a great point would have been gained. No doubt the cost of these electric lamps was a great drawback to their use. He hoped they might see them still more simplified, and brought within the means of working miners. No doubt the workman would rather give more for a good light, and it was to their interest to encourage such inventions as these.

Mr. FLETCHER said he could not help echoing the President's remark, that the workman would rather give more for a good light. That was a fact that could not be made too widely known. Assuming the ventilation to be good, he defended the use of the common candle in mines, on the score of its handiness, and said he could not but think that much time was given needlessly to the question of explosions from the misuse of lamps, or from the use of defective ones, rather than to the question of the presence of gas, and the continuance of work in its neighbourhood. He regretted that the commercial element entered so largely into mining engineering; it did so, he thought, more in this county, where the engineer was often in a position of subordination to the colliery salesman, than elsewhere—and he did not expect that engineers would reach the highest standard in practice, or workmen get the full benefit of their skill, until there was an Employers' Liability Act requiring all masters to guarantee their men against accident of all kinds—in other words—till they were made to feel, in their pockets, the effects of every accident that happened. When men became scarcer, they would probably be able to enforce their demand for a return to the use of the best, and indisputably the handiest, light—the candle—and for such a system of working, and for such ventilation, as would in the great majority of cases render the use of that best and handiest light safe. He advised the profession and the trade to be beforehand with this demand, and meet it voluntarily rather than yield to pressure.

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Mr. J. S. Burrows, replying to some of the remarks of Mr. Fletcher, said, that the Employers' Liability Act had been from the commencement and was now in force at their collieries, and it had not made the slightest difference to anyone concerned in their efforts for the safety of those employed, and they were spending time and money on the electric light because the electric light was one thing which would make miners a good deal safer than they are now.

A PATENT SAFETY CAGE.

Mr. E. Ormerod exhibited a model of his patent safety cage, and explained its working. The invention, he said, was a recent one. It consisted of a patent catch, which, in the event of a rope breaking, immediately came into action, and prevented the cage from falling down the shaft.

The President pointed out some respects in which Mr. Ormerod's invention resembled others previously introduced. In particular, an iron rod at the head of the cage was a disadvantage, from its liability to injury. Otherwise he thought the model an excellent one.

The thanks of the Society were given to Mr. Ormerod.

THE GEOLOGICAL SURVEY OF CHESHIRE.

Mr. De Rance, of the Geological Survey, said: I shall have finished by the end of this month—the geological survey of the Cheshire salt districts. As you know, that district has come very much into prominence of late owing to the formation of the Salt Syndicate, and also from the occurrence of subsidences in various places. In the course of my survey I have made a point of tracing the lines of

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fracture, and areas of subsidence upon the maps of the 6-inch scale; but I am sorry to say that Cheshire is not one of the counties which the Geological Survey publish on that scale. An effort is being made in some directions to have all the coal-fields and mineral districts in England and Wales mapped and published on the larger scale, but under the present regulations these maps are not to be published. The same applies to the Cheshire salt-field, but if any members of the Society—or anyone interested in the salt district—should at any time want a 6-inch map of that district, they will be able to have it copied. Upon the maps are represented all the various drift deposits, the lines of subsidence, position of shafts, and so forth. Several interesting points have come out as regards the salt subsidences, in regard to depressions in the surface of the Glacial Drift, which covers the district pretty thickly, which appear to have a direct relation to the outcrop of the salt rock underneath. As you all know, and Mr. Dickinson has clearly brought out, in his able reports on the salt districts, there are two salt beds, and at one time or another —in Geological time probably—they had an actual outcrop. That outcrop has been worn back by absorbed rainfall melting the rock salt and running down the dip planes of the strata, a process which is still further wearing back the line of original outcrop. When you examine the drift map, you find that there is a chain of meres or small lakes, and in between are peat mosses which represent original lakes; in other words, you have a line of lakes or meres and old peat mosses which correspond in direction to the strike of rocks underneath, and consequently to that of the original crop of rock salt beds. There are two distinct lines which correspond to the original outcrop of the two beds of rock salt. In the district south of Winsford, it is very striking to observe how very rapid the subsidence has been. The

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6-inch Ordnance map was only made a few years ago—in fact as regards the contours it is hardly complete yet—yet, when you go upon the ground, you find in the eight or ten years which have elapsed, the lakes or "flashes" caused by subsidence have encroached in all directions, and the fields adjacent are all in a series of steps, which steps do not all run parallel to the main valley but in lines tributary to it, something in plan like the branching of a tree, showing that there are rills underground running after the fashion of rills on the surface,—that is, towards the main stream, in other words, the whole of the slopes on either side of the Winsford valley are in motion. No district could be more interesting for members of this Society to visit than the district between Northwich and Winsford, and on towards Delamere, where, amongst the charming scenery, you find the most extraordinary circular pits, almost like the craters of volcanoes, filled with water at the bottom, occupying sites which within the memory of farmers at present living in the district, were smiling corn fields. Should the Society feel inclined to go over that district next summer, I shall be pleased to assist in conducting the expedition.

Mr. STIRRUP, moved a vote of thanks to Mr. De Rance for his address, and, as one of the Honorary Secretaries, said he should be glad, on behalf of the Society, to accept the offer made by that gentleman, probably next summer.

Mr. DICKINSON, seconded the vote of thanks, and expressed a hope that arrangements would be made at the same time, for a visit to one of the old rock salt mines in the district of Northwich.

The vote of thanks was unanimously passed.

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DANGER IN THE STEMMING OF SHOT HOLES.

Mr. GRUNDY, H.M. Inspector of Mines, brought under the notice of the Society an experiment, which, he said, was similar to one shown to the members by the late Dr. Angus Smith, illustrating how heat, in quantity sufficient to ignite gunpowder, was generated by the sudden compression of air in a confined space. This experiment, in Mr. Grundy's opinion, proved the danger which attends the incautious stemming of shot holes in mines where blasting is practised, and especially in cases where the wadding, or stemming, is rammed violently down the holes.

The thanks of the meeting were given to Mr. Grundy for his communication. The PRESIDENT observing that he believed it to be quite possible for an explosion to take place in the manner suggested, if the fireman was ignorant of the fact that heat was generated by the forcing of stemming into the shot hole.

Mr. HERBERT FLETCHER said, Mr. Grundy's communication had opened his eyes to the danger of the use—or the non-immunity from accident in the use—of the water-cartridges. The space outside the bag containing the water, and between it and the sides of the hole, would be filled with air. The sudden explosion of the dynamite inside the water would compress the air, as the air was compressed in the tube with which Mr. Grundy had experimented, and they might in that way have great heat generated outside the water in particles of air or gas, or coal or coal dust, or even rock, with which the water was prevented from coming in contact by the sides of the bag. He had never seen the possibility exemplified before. They had all probably

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heard of experiments with water-cartridges, in which sparks were seen.

Mr. DICKINSON said those members who were present when Dr. Angus Smith exhibited his apparatus for testing the presence of fire-damp, would recollect that, instead of a brass tube such as Mr. Grundy exhibited, he had a glass tube, so that it could be seen what took place inside. Dr. Angus Smith was able to strike a light simply by the compression of the air when it contains one or two per cent. of gas. In a better constructed instrument, made after by Mr. Dancer, the optician, there was no difficulty in producing this spark without any gas being present at all in the air. The air itself when compressed emitted one spark, but no more. A second spark could not be produced from the same air. Fresh air was required for the success of each experiment. The result of these experiments had been embodied, so far as it practically could be, in the rule as to explosives in the new Mining Act, where it was stated that no cartridge was to be forced violently into a hole; which was intended to apply not only to the possibility of firing the powder by the compression of the air, but also, particularly to bobbin or compressed powder, striking fire upon any little projection in the hole, through the hole being imperfectly drilled.

Mr. FLETCHER said he thought Mr. Dickinson would agree with him, that in the use of the water-cartridge the larger the hole the greater the danger, because there would be more air subjected to compression.

Mr. DICKINSON said it was a pity they had not Mr. Settle present. He regretted to say that he was just now out of health and had been obliged to go to the Continent. When he could attend, it would be a good opportunity to have a discussion upon the point Mr. Fletcher had brought forward.

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Mr. Bramall said the water-cartridge had been in extensive use at the collieries with which he was connected for more than twelve months. It was placed in the hands of shot-lighters specially trained for the work, and they had all been particularly instructed to take note of every shot, and, if they saw a spark, to report it. It had also been tried by the managers and others of the staff, and, up to the present time, no report had ever reached him of a spark or a light having succeeded the explosion of a water-cartridge. He supposed they had fired some thousands of them.

Mr. Fletcher said he did not think sparks would necessarily be thrown out, but might be confined to the hole. If there happened to be a fissure, and a feeder of gas behind the hole, the gas might be lit, and so lead to the same disastrous results which are supposed to have occurred from the firing of powder, before the introduction of the water cartridge.

Mr. Bramall said he merely spoke from the results of his own experience and practice, without reference to any theories.

Mr. Fletcher said there would be no spark visible in such a case as that. The heat would be generated in the hole behind the envelope of water, or around it, and the sparks might not be thrown out. The effect of the sudden compression would be to make the air hot enough to light the gas, which might be left burning. But in the case of experiments tried in the open air above ground he could easily understand a spark being visible.

Mr. Grundy said that one of the lessons to be learnt from these experiments was that miners ought to be taught to carry out that general rule which Mr. Dickinson had mentioned and not violently force powder into a hole. The hole should be drilled of such a size that the charge would go in easily, and without the employment of force.

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The PRESIDENT: The proper method of stemming a hole is to put the stemming in lightly, to begin with, and keep adding on till you stem it tight. The effect of forcing it in is to compress the air, as has been described, and generate heat.

Mr. GRUNDY said it was no uncommon thing to see men, in stemming a hole, take a plug of paper, or damp earth, and shape it in the hand to the size of the hole and then force it in.

The PRESIDENT: Yes, but if it is not driven in so as to compress the air there is no danger.

Mr. GRUNDY: Everyone knows that when a collier is ramming a hole, if he meets with resistance, he goes at it with all his might.

Mr. FLETCHER: The force exerted in stemming a hole would be as nothing to that exerted by the explosion of a dynamite cartridge. You must have air all round the bag. As you increase the pressure upon the bag you shut in that air, and the effect of its sudden compression by the explosion of the cartridge, must be the generation of sufficient heat to cause the ignition of any gas and air that may be at the back of the hole.

The discussion then ended.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XX. SESSION 1888-9.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 11th, 1889, in the Mining School, Wigan.

The President, Alderman JOHN KNOWLES, Esq., M.Inst.C.E., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. JOSEPH DOBBS, of Coolbawn, Castlecomer, Co. Kilkenny.

Mr. J. K. MOORE, C.M., 36, Prince's Street, Douglas, Isle of Man.

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Mr. G. H. Hollingworth (Honorary Secretary) announced that arrangements were being made for the holding of an Evening Meeting in the Museum of the Owens College, on Tuesday, the 29th inst., when the geological and natural history collections would be open for the inspection of the members.

A paper had also been promised by Mr. P. H. Kendall, on the Volcanic Rocks of the Island of Mull.

PREMATURE EXPLOSIONS OF GUNPOWDER.

By Mr. James Grundy, H.M. Inspector of Mines.

The short paper that I propose to bring before the Society to-day, and the experiments to illustrate it are, in great part, reproductions of those I brought before the last meeting of the Society in Manchester; but as they were then brought on near the close of the meeting, I have been requested to bring them before you to-day.

The experiment is but a small one, but in all essential particulars it is very old; having been a favourite at Physical Science Lectures for a large number of years. It is not at all new to this Society, for the late Dr. Angus Smith described and exhibited the apparatus, some years ago, to illustrate a paper read by him; and Mr. Dickinson made use of the principle involved, in a Report which was presented to both Houses of Parliament in 1887, on the Udston Colliery Explosion.

But a good experiment can often be made to illustrate and explain many occurrences, which do not at first sight appear to have anything in common; and I offer this one as a probable explanation of some premature explosions during the stemming of shot holes.

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There have been several cases of gunpowder exploding while the hole was being stemmed with a wooden stemmer, and similar accidents have occurred when copper stemmers were being used, and several theories have been brought forward to account for them. If two hard stones be made to strike each other, you can get feeble sparks; and I believe it has been suggested that some of the premature gunpowder explosions have occurred through a piece of hard stone, that may have stuck into the end of the wooden stemmer, striking fire at another hard stone on the side of the drill hole. And also where a copper stemmer was being used, by the copper striking fire against a piece of iron-stone, or other hard stone, on the side of the hole. Simply speaking of my own observations, I have never seen but very feeble sparks, either when two hard stones have been struck together, or when a hard stone has been struck with copper. But the sparks given off when copper is being used, depends a great deal on the hardness, both of the copper and the stone struck; and from the fact that both copper and brass are hardened by rolling and hammering, it seems to be a natural inference, that the more a copper or brass stemmer is used, the more likely it is to give off sparks when struck against something hard. As the days of iron stemmers is past, their use being illegal, an accident caused by such a stemmer would scarcely be described as premature; I shall not therefore say any more on that point.

My experiment may be looked upon as an alternative way of accounting for premature explosions of gunpowder during stemming; and I propose to explain it by drawing a comparison between such an accident as has been referred to, and the experiment itself; directing your attention to the similarity between the conditions prevailing in the two cases. I have been told of an accident which is believed to

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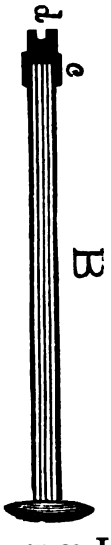
have occurred under the following circumstances:—A collier had drilled a shot hole, and was proceeding to charge and stem it. He put his charge of bobbin powder and fuze into the hole, and then followed what the collier himself described as "a big handful of paper;" and he declared that he was in the act of pushing this paper wadding down the hole, by means of a copper stemmer, when the powder exploded.

Now compare the conditions with this apparatus, and the experiment to follow. Description:—A (on sketch) is a brass tube, having one end made air-tight by means of a screw and leather washer. This tube is to represent the shot-hole, and may be made of brass, glass, or any other suitable material. B is a brass rod to represent the stemmer, and is made to fit air-tight in the tube by means of a leather ring (c). This leather ring may be taken to represent the wadding, or paper, which was being pushed into the hole. The charge of gunpowder is kept in front of the stemmer and wadding, and protected from any effects of friction, by being placed in a small cavity (d) at the end of the rod. Now if the rod be made to carry the charge and air-tight wadding, quickly and forcibly too near the bottom of the tube, the compressed air in front will give off sufficient heat, *at one stroke*, to ignite the gunpowder. I will now show this. (Experiment performed.) You saw that as soon as I pressed the piston down with my hand, it was forced back again, and sparks and smoke rushed out of the tube; showing that the heat given off by the compressed



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air had fired the charge of gunpowder. And that there was not any churning of the air required, one small stroke being quite sufficient.

Some small portion of a paper cartridge may possibly be in the condition of a piece of touch-paper. This may be the first to ignite, in such a case, and transmit the heat to the enclosed charge. I will, therefore, repeat the experiment, which I can do quite as effectively by using touch paper, made by steeping ordinary blotting paper in a solution of gunpowder (experiment repeated). You see again that one small stroke of the piston is sufficient to set the touch-paper burning, as you are now observing it do, at the end of the piston.

At the last meeting, Mr. Herbert Fletcher suggested that it was quite possible for the air surrounding the outside of a water-cartridge, to give off sufficient heat, by being suddenly compressed at the time the explosion takes place inside the cartridge, to ignite any firedamp or to render incandescent any coal or rock dust, that might be in the shot-hole. He also said that water-cartridge charges when exploded, sometimes emitted sparks, and ascribed the same reason for it. But Mr. Bramall said he had never heard of any sparks from shots, fired with water cartridges at their collieries, although they had used some thousands during the last year; their shot-lighters having been particularly instructed to take note of every shot, and if they saw a spark to report it. Mr. Dickinson, referring to General Rule XII. (e), of the New Mines Act, where it is stated that "no explosive shall be forcibly pressed into a hole of insufficient size," said that "this was stated not only with regard to the possibility of firing the powder by the compression of the air, but also with regard to the powder—particularly

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bobbin powder—striking fire upon any little projection in the hole, through the hole being imperfectly drilled."

Some of the matters brought before you in this paper are such that differences of opinion may be reasonably entertained, and about which the experiences of members may greatly vary; I shall, therefore, be very glad if members will take this opportunity for ventilating their opinions, and relating their experiences on the matters referred to.

A vote of thanks having been passed to Mr. Grundy.

Mr. Herbert Fletcher said he felt most keenly the value of such papers to the Society as the one Mr. Grundy had contributed on the premature explosion of gunpowder, which seemed to him—and it had come as a sort of revelation—to suggest a possible cause of at least one of the disastrous colliery explosions which had occurred where the water-cartridge had been in use. The experiment had shown what force could be exerted by the arm of the operator. It had shown also, that by compressing the air between the cartridge and the rock or coal surrounding it the explosion could generate intense heat beyond the influence of the water. He obtained information during the two last midsummer excursions of the North of England Institute and the Midland Institute in Scotland, and also on the Tyne, of experiments with water-cartridges, in which sparks were seen several times which could not be accounted for. These experiments were conducted in the open air and at night, where the effect of the water in all directions, and not outwards alone, could be better seen than in the mine. Mr. Grundy had demonstrated that he could generate red heat by compression alone, and no matter how small the

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quantity of air compressed, and whether powder or any other explosive substance was used, it was only a question of degree of compression, and of the separation of the heat so generated from the water by the cartridge bag. Mr. Grundy's experiment proved conclusively in the simplest and most irrefutable manner that no explosive substance was to be trusted where it was not safe to use it without water, and any coroner's jury investigating the occurrence of any explosion would be justified in returning a verdict of manslaughter against any manager who so used and trusted that explosive. He did not think they could say too much of the importance of Mr. Grundy's paper. The experiment itself was not new, but this application was. It not only showed how fire might be generated in charging a shot, but it showed how fire must be generated in the discharge of a shot, behind the cartridge case and removed from the quenching influence of the water. He had had great pleasure in listening to what Mr. Grundy had said, feeling that he had put one more spoke in the wheel of those who would bring science to aid in the extracting of coal under circumstances that were not allowed by the Act of Parliament, viz., where it was not safe to use an open light, and the dust was not damped.

Mr. R. B. Mawson said he would like to ask Mr. Grundy if he could get air red hot in a hole three feet long and an inch and a half in diameter.

Mr. Grundy: I am obliged to tell Mr. Mawson that I do not know.

Mr. Mawson said the experiment of Mr. Grundy was a very old one, and consisted simply of compressing a very small quantity of air in a tight-fitting cylinder, and it was easy to see that that could be easily compressed into a red heat, and Mr. Fletcher put it very forcibly when he said

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that gunpowder was not safe to use under those circumstances, but they must bear in mind that comparisons did not agree with the conditions of a hole down the pit three feet long and an inch and a half in diameter. They would get very much more air in the hole, and it would be a very difficult or impossible thing to get that red hot.

Mr. GRUNDY said he did not quite agree with Mr. Mawson. Take for instance a man putting a charge of powder into a shot hole, then putting a handful of paper into the hole and pushing it towards the end. It was not very likely that the paper would go from one end of the hole to the other. Possibly he would push the paper wadding until he felt the compression of the air in front of it and would think it was some other resistance, and then perhaps for the last few inches so compress the air that it would give off sufficient heat to ignite the powder.

Mr. HALL said he thought there was a difficulty about the experiments, because in the tube used by Mr. Grundy the imprisoned compressed air at the beginning would be forced right down to the end; but, as Mr. Mawson had pointed out, if he was dealing with an ordinary drill hole, a man would put in his charge of powder at the end of the hole only, and then he got his paper so that his column of air was a very short one, and could not be compressed in the way it was in the experiments, and for that reason he was inclined to agree with Mr. Mawson that heat could not be got up in like manner in an ordinary drill hole.

Mr. SAINT asked whether Mr. Grundy could arrive at the same result with a shorter column.

Mr. GRUNDY said he thought it could be arrived at under similar conditions. A man did not get his paper and wadding into the hole at once so as to render it

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airtight, but could he not do it when pushing the paper down the hole? Really he was compressing the air, and any man in that way could cause the powder to explode.

Mr. HERBERT FLETCHER said he agreed that it was impossible to cause a premature explosion in any hole by air compression without raising the air to a great temperature. The heat did not depend on the quantity of air but on the degree to which it was compressed.

The PRESIDENT said he thought Mr. Grundy's idea was to show that the compression of air into a small space created heat, and therefore caused an explosion, and Mr. Fletcher took up the idea that there were certain instances of the compression of air outside water-cartridges. There was another point raised as to powder being put into a hole and gradually pressed forward, compressing the air, and thereby causing an explosion. It was, he thought, a very rare occurrence that the stemming was so suddenly pushed forward as to rapidly compress the air; it might, however, occur under the conditions laid down by Mr. Grundy in case strong wadding was used. It was very proper that the subject should be discussed and brought to the knowledge of the Society, so that the members could think it over. There were times they did not know the why and the wherefore of an explosion, and such papers and experiments would enable them as mining engineers to conduct their work with much more safety.

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ON THE USE OF ROBURITE IN COAL MINES.

By Mr. James Hilton.

Roburite is a very powerful explosive, and as many of you are aware, was invented by Dr. Roth, a German chemist, in 1886, and was first used in this country in 1887.

It belongs to the class of what is called high explosives, but without the disadvantage unfortunately possessed by some of them, in their liability to accidental explosion under certain conditions, by percussion or becoming very dangerous, by undergoing chemical, molecular or mechanical changes.

Explosives may be divided into two classes, first, gunpowder; and second, nitro-compounds. Of the former you all know what a very many valuable lives have been lost through its use in fiery and dusty mines.

The latter class, before Roburite was invented, was found to be very little, if any, safer than gunpowder, until some of them were rendered safe by that very valuable and ingenious discovery of the water-cartridge.

Roburite consists of two component parts non-explosive in themselves, but which, when mixed, form a very powerful explosive. It is especially valuable on account of the perfect safety with which it may be transported and stored, neither friction, percussion, nor heat will cause it to explode. A strong detonator being required to explode it. Under pressure it is practically flameless. The gases evolved in its combustion being such as to quench any initial flame there may be. In fiery mines it should be tamped so as to

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confine the gases, and give them a chance of acting on the initial flame at the moment of ignition. The quenching element being chlorine. Hydro-chloric acid gas is given off on explosion, and, being incapable of supporting combustion, it prevents the spreading of the flame. The effect is very similar to the water-envelope in the water-cartridge. In Roburite, the quenching element is certain to be always present, but this is not so in the water-cartridge—either through the cartridge leaking, like I have known one to do, the result being that a large flame came from the shot-hole on the shot going off, or through the shot-firer wilfully omitting to put water in the cartridge, which has been done frequently.

The following memorandum upon the gases evolved by the decomposition of Roburite is given by the inventor:—

Memorandum upon the Gases evolved by the Decomposition of Roburite.

1. There are no noxious nitrous fumes evolved by the explosion of Roburite—but like every other explosive,—nay, every other combustible substance, it must produce a certain amount of carbonic acid gas. But the following investigation will shew that the gases are perfectly harmless, thus bearing out the practical experience of all those who have been present at the explosion of Roburite.

Dr. Carl Roth gives the chemical equation for the decomposition of Roburite as follows:—

$$\underbrace{C_6 H_3 Cl (NO_2)_2}_{\text{(Organic)}} + 9 \underbrace{NH_4 NO_3}_{\text{(Inorganic)}} = 6 CO_2 + 19 H_2 O + 20 N + H Cl$$

putting the molecular weights in place of the above symbols—

$$[202{\cdot}5 + 720] = [\underset{\text{Carbonic Acid.}}{264} + \underset{\text{Water.}}{342} + \underset{\text{Nitrogen.}}{280} + \underset{\text{Hydrochloric Acid}}{36{\cdot}5}]$$

$$922{\cdot}5 = 922{\cdot}5$$

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2. A charge of 100 grammes Roburite (1543·2 grains or nearly ¼ lb.) may be taken as about the largest which would be fired in any one shot in the gallery of a mine.

The 922·5 : 264 = 100 : x χ x = 28·6 grammes carbonic acid gas. If the above amount be diffused in even the most confined space, say four metres each way, that is 64 cubic metres of air. Now a cubic metre of air (1000 ltre. = 1 cubic metre) weighs 1,293 grammes,—64 cubic metres = *82,752* grammes. Into this weight of atmospheric air is dispersed an additional quantity of 28·6 grammes carbonic acid, which is a proportion of 0·034 per cent. The normal percentage of carbonic acid contained in atmospheric air is 0·04.

A single workman, of about 24 years of age, exhales 44·7 grammes of carbonic acid per hour. In the above calculation no allowance has been made for the rapid diffusion of the air, which, in a few seconds, would remove the surplus percentage of carbonic acid. In fact, the effect would be practically "nil" compared with that of an ordinary London fog, since it has been computed that, in the latter case, the amount of carbonic acid gas contained in the air is increased about fourfold. Those who were close to the Roburite shots fired in coal mines can testify that the air, close to the shot, immediately after the explosion was far better than is the case in the Underground Railway.

Roburite gives rise to no dense nitrous and other poisonous fumes as do dynamite and gun cotton.

The following memoranda and rules for using Roburite have been arranged and adopted by me after the experience gained in firing over 3500 charges in mines under my control:—

1. Roburite can only be exploded effectively by a specially strong detonator, containing one gramme of fulminate of mercury.

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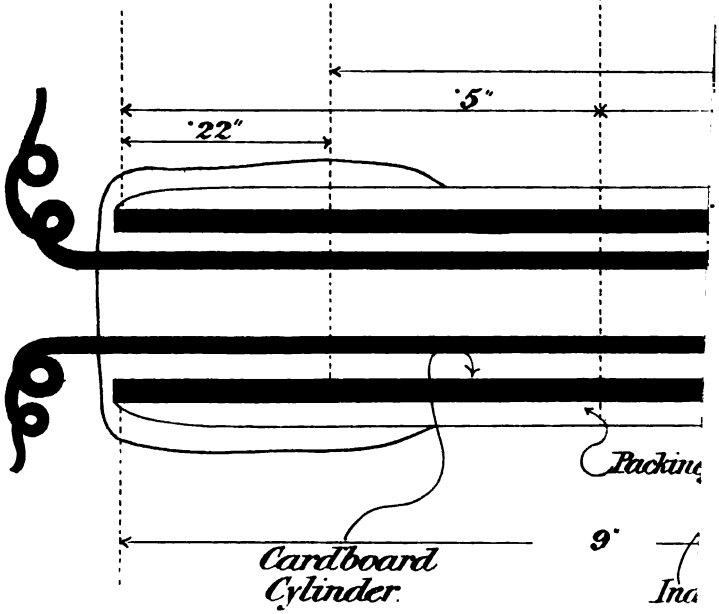

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. The drill hole must only be a shade larger than the meter of the cartridge, and is more suitable when machine led.

. Open one end of the cartridge, bore a hole down the tre of it, with a wooden peg, and then insert the detona- well into the middle of the cartridge. Next, tie the ering of the cartridge firmly to the fuse.

4. In tamping, be careful to use dry material, and to m the hole very lightly for the first three or four inches, as not to displace the detonator or compress the Roburite. fterwards tamp firmly for not less than a foot with clay or amp'd borings from the drill hole. This rule is most mportant as the safety of the explosive depends on the amping.

5. Fire the detonators with an electric fuse where fire-damp is given off or coal dust is present.

6. Store the Roburite in a dry place, and if the hole is wet fire the charge as quickly as possible after it has been placed in the hole.

7. If the charge misses fire, disconnect the cable from the battery, and wait ten minutes before going to it. For although there has not been a single case of hanging fire with me in over 3500 shots, yet I have heard of an accident happening through a shot hanging fire for a few minutes. It is supposed that the paper at the end of the electric fuse inserted into the detonator, smouldered for a short time, and fired the fulminate of mercury.

The accompanying section of an electric fuse and detonator will assist in showing how it is possible for such an unexpected thing to occur.

I append hereto particulars of some of the most important experiments, together with a drawing of the apparatus employed in some of them.

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ROBURITE EXPERIMENTS, ALEXANDRA PIT.

Pemberton 4ft. Mine, 22nd December, 1887.

Present: Messrs. W. H. Hewlett, Bigg-Wither, Ward, Hilton, Webster, Dean and Herr (chemist), and Mr. Hall (H.M. Inspector of Mines).

No. 1.—Coal holed 3ft. 9in., drill hole 2ft. 10in., would take 12oz. powder to blow the coal; put 1 cartridge (*i.e.*, 4oz.) and 2ft. of tamping. Did not make much report, and did not blow tamping or coal, but loosened the coal a little; seemed to be short of power; no light or sparks at all.

No. 2.—Coal holed 3ft. 9in., drill hole 2ft. 10in., would need nearly 12oz. powder; put 1½ cartridges in, equal about 6oz. of roburite. Made very little report, and did not blow either tamping or coal (2ft. tamping); no light or sparks at all.

No. 3.—In 4yd. heading, coal holed 3ft. 5in., drill hole 2ft. 9in., would need rather better than 12oz. powder; put 2 cartridges in (*i.e.*, 8oz. nearly), 12in. tamping. A missed shot.

No. 4.—Coal holed 3ft. 4in., drill hole 2ft. 10in., would use 12oz. powder; put 2 cartridges in and 14in. of tamping. Would not fire at first, and then went off with very little report; did not blow the coal, but loosened it a little; no one watched for flame or sparks.

No. 5.—Fast shot for a blown out shot, hole 3ft. 4in.; 1½ cartridges and 6in. tamping. There was a decided ray or flash of light, with sparks, which seemed to be brighter when it got to the other side of the place. Messrs. Hewlett, Hall, and Webster saw this, and also several other officials of the company. The others said they could not see anything.

No. 6.—Same hole as last; 2 cartridges and 6in. tamping. Result same as No. 5, though more decided. This was seen by Messrs. Hewlett, Hall, Hilton, and Webster, and also several other officials of the Company. The others said they could not see anything still.

No. 7.—Fast shot blown out on opposite side of place to the last two. Hole, 3ft. 4in., 1½ cartridges, 12in. tamping. No sparks or light were seen.

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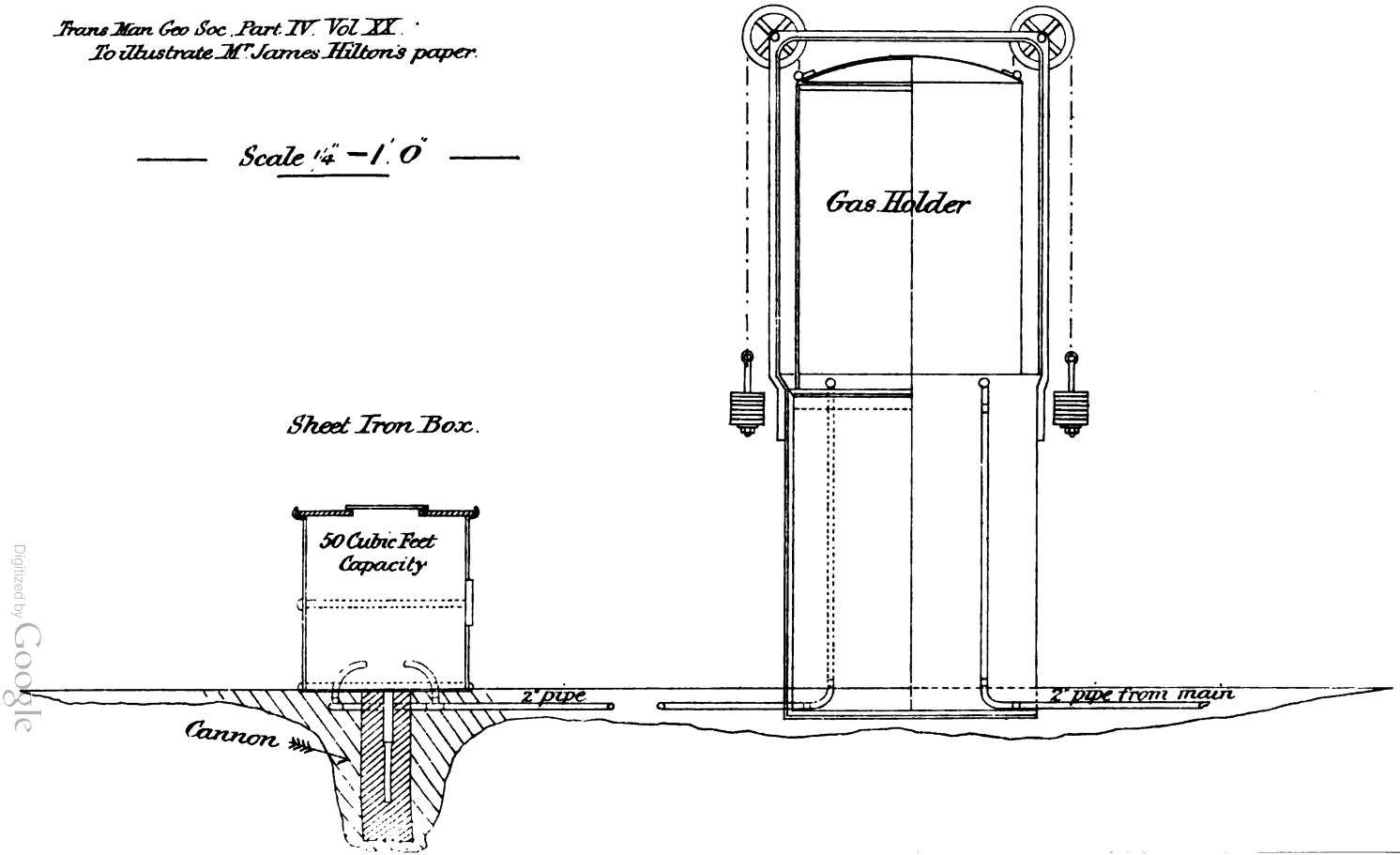
Trans Man Geo Soc. Part IV. Vol XX.
To illustrate Mr James Hilton's paper.

Scale 1/4" = 1' 0"



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No. 8.—Same hole as No. 7. Blown out shot; 2 cartridges, 12in. tamping. There was a ray or flash of light with sparks, which seemed brighter on opposite side of place; not so decided as Nos. 5 and 6; this was observed by everyone watching.

NOTE.—The tamping used was soft warrant in all cases.

All shots were fired by No. 24 explode and No. 5 detonators.

The cartridges used in the experiments had come from Germany and were old ones, and this would account for some of them having deteriorated, and therefore either not going off or not blowing the coal.

The following arrangements and experiments have been made by the kind permission of Mr. W. H. Hewlett, at the Wigan Coal and Iron Company's Works, in order to further test the safety of roburite.

Present: Messrs. W. H. Hewlett, Webster, Hilton, R. B. Mawson, Dean, Cockson, Leach, and Mr. Hall, H.M. Inspector of Mines.

The apparatus consists of the following (see drawing):—1, A gas holder, from which gas is conveyed by means of wrought-iron pipes to 2, a cannon placed vertically and the mouth upwards. The diameter of the bore is 2in. at the top and 1¾in. at the bottom, and is 30in. long. There is a gas jet on each side of the mouth of the cannon, and over them is placed a sheet-iron box 3ft. 9in. square and 3ft. 11in. deep. It is without bottom and the top is fitted with a loose wood cover with an 18in. hole in the centre for the force of the shot to escape. This hole is covered with a piece of light oiled canvas. At one side of the box is a hole for testing the gas mixture. At some previous experiments canvas boxes were used, but were not found sufficiently durable.

1st EXPERIMENT.—Charge 4oz. of blasting powder, 4in. tamping. Fired into an explosive mixture. Large flame and top of the box blown off, and gas-jets left burning.

2.—4oz. powder, 4in. tamping. Without gas; large flame.

3.—2oz. Roburite, 4in. tamping. Without gas; no flame or sparks.

4.—2oz. Roburite, 4in. tamping. Without gas; no flame or sparks.

5.—2oz. Gelignite, 4in. tamping. No gas; moderate flame.

6.—2oz. Roburite, 4in. tamping. Fired into an explosive mixture; no flame or sparks.

7.—Same again; no flame or sparks.

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8.—Same again; no flame or sparks.

9.—2oz. Roburite, no tamping. Box removed and no gas; flame about 18in. long and very bright.

10.—2oz. Roburite, no tamping. Fired in box full of inflammable mixture. Result explosion with about 20ft. of flame, and the gas at the pipes left burning.

11.—2oz. Roburite, 4in. tamping. Fired into explosive mixture; no flame or sparks.

12.—2oz. Roburite, 4in. tamping. Fired into explosive mixture seemed to show a little light; gas not lit.

13.—Detonator fired in explosive mixture, without lighting it.

14.—3oz. Roburite, 4in. tamping. Fired in explosive mixture; did not light the gas; flash, but apparently no flame.

15.—4oz. Roburite, 6in. tamping. Fired in explosive mixture; no flame or flash seen.

16.—4oz. Roburite, 6in. tamping. Box removed and gas turned on; light seen but no flame.

17.—3oz. Roburite, 7in. tamping of dry coal dust. No box, gas turned on; no light seen.

18.—4oz. powder, 6in. tamping of dry coal dust. Very long flame and a loud report produced.

The following are some Roburite shots in the yard mine floor at the Woodshaw Pit belonging to the Wigan Coal and Iron Company, that I went down to watch specially for sparks or flame:—

No. 1 Shot.—In very hard floor; hole 18in. long and dipping about 1 in 2, thickness to be blown 15in., charge 4oz., would take 8oz. of blasting powder, tamping 12in. No sparks given off, but a very small dull red flash was seen.

No. 2 Shot.—In hard floor; hole 34in. long, thickness blown 15in., charge 6oz., tamping 27in., dip of hole 1 in 2. Neither flash nor sparks seen.

No. 3 Shot.—In hard floor; hole 34in. long and dipping 1 in 2, thickness blown 24in., charge 8oz., tamping 24in. Neither sparks nor flash seen.

No. 4 Shot.—In hard floor: hole 34in. long, charge 8oz., tamping 24in. Faint reddish flash seen, but no sparks.

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No. 5 Shot in coal.—A cutting shot; coals holed 36in. underneath, hole 35in. deep, 3oz. charge, hole bottomed, coals about the shot shattered. Neither sparks nor flash seen.

No. 6 same as No. 5. Neither sparks nor flash seen.

No. 7 same as No. 6. Neither sparks nor flash seen.

No. 8 same as No. 7. Neither sparks nor flash seen.

No. 9 Shot.—A very weak one in hard floor, with a slip running along the side of it; hole 18in. deep and dipping 1 in 2, thickness blown 15in., charge 4oz., and 13in. tamping. Dull red flash seen, but no sparks.

No. 10 Shot.—In hard floor; hole 34in. deep and dipping 1 in 2, charge 6oz., tamping 27in., thickness blown 15in. Neither flash nor sparks seen.

No. 11 Shot.—In hard floor; hole 34in. deep and dipping 1 in 2, charge 8oz., tamping 24in., thickness blown 24in. Neither flash nor sparks seen.

No. 12 Shot in very hard floor. Hole, 34in. deep, and dipping 1 in 2; charge, 8oz.; tamping, 24in.; thickness blown, 24in. Faint reddish flash seen but no sparks.

In the number of roburite shots I have already mentioned either sparks or a flash have been seen on an average once in a hundred times. But in none of these that I have seen do I think an inflammable mixture would have been ignited, although the margin between danger and safety would in that case have been very small. This I consider a satisfactory result, but I hope that if anything further can possibly be done by the Roburite Company to prevent sparking they will do it, and thus render their explosive, with due precaution in tamping the charges, absolutely safe.

Mr. W. S. Barrett said he had great pleasure in proposing a vote of thanks to Mr. Hilton, not only for the benefits he had conferred upon the Society by reading the paper, but for the time he must have spent in its preparation. The question of explosives was a serious one to the colliery owner, and any one who could give them any information

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upon it, and especially about roburite, was entitled to their hearty thanks.

Mr. C. Cookson seconded the motion, and said he could cordially re-echo what Mr. Barrett had stated. Although some of the experiments were not new to him, he having had the privilege of witnessing them at the Wigan Coal and Iron Co., yet he was sure the paper would be read with a great deal of interest, as the subject was of great importance to the colliery industry.

Mr. Herbert Fletcher said that paper afforded him another opportunity for a word of warning against placing reliance on any explosive, which depended on the use of water or other quenching substance in a cartridge case to prevent the issue of sparks in places where the absence of gas was not first of all ascertained. In all coal mines maintaining ventilation was the chief item in the "dead" or not directly remunerative part of the cost, and there was always a temptation to shirk this expense. They should guard against the tendency of the use of any kind of apparatus which seemed to render the shirking of this duty possible. He believed in the great majority of mines explosives of any kind might be used without danger of gaseous explosion, but the claim to flamelessness of the new explosives should not lead to reliance being placed on that claim, instead of on ventilation and watering.

Mr. C. F. Clark said that in listening to Mr. Hilton's paper, what had more particularly struck him was this, that by use of roburite the explosions, which had been so ably illustrated by Mr. Grundy, would not be liable to take place, because he understood that neither by concussion or heat or sparks could roburite be exploded. It must be by the use of a powerful detonator, and that, however air might be compressed into the hole by

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the use of roburite they were not liable to have an explosion similar to what they would have from gunpowder, and, therefore, he thought roburite was much safer, and that they would get on better by its aid than by the use of gunpowder. He certainly thought from all the experiments he had seen and made, and they had been considerable in number, that it was a much safer explosive than gunpowder. They knew that with gunpowder when a blown-out shot took place it gave off a very large flame indeed, especially if the hole had been tamped with dust. Now, with roburite they had nothing of the sort. It was possible that sometimes they might have a glare, but he had never seen any sparks, and he believed that however far that glare extended, or how short a distance from the mouth of the hole, that it was not dangerous. He had tried it without any tamping whatever, and the force exerted seemed to have been as much as if the hole had been tamped. Whatever Mr. Fletcher might say he did not believe that any manager would attempt to fire a shot of gunpowder or roburite or any other explosive if there was any gas existing, or if any had recently been seen.

Mr. W. Watts asked if he was right in supposing that roburite was only twice the strength of gunpowder. Mr. Hilton had given four ounces of gunpowder to two of roburite.

Mr. Hilton said that theoretically it was much stronger, but they called it twice the strength of gunpowder.

Mr. Watts said for tunnel-driving through rocky strata he thought powder had not been superseded. He had been engaged in blasting a tunnel, and his experience was that there was nothing better for rocky strata than powder combined with tonite in wet ground. Powder, it was patent to him, was not an explosive they could put on one side for tunnel driving, but he did not advocate its use in fiery mines.

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Mr. T. D. Grimke said he would like to make a few remarks on his experience of roburite. Supposing there was any air round the cartridge if the chlorine extinguished it at the same time it extinguished the flame, then roburite had an element of safety in its use which gunpowder or the water-cartridge could not have. He believed that as far as tunnelling was concerned roburite was almost equal, if not superior, to gunpowder. He might say that at Messrs. Evans' collieries they were driving tunnels of considerable length, and there was very little difference in the power of roburite and gunpowder; in fact, one of the men took the contract on condition that he would be allowed to use the former.

Mr. W. Bryham, jun. (Wigan): I should like to ask Mr. Hilton if he has known any ill effects arise from the roburite fumes?

Mr. Hilton: I have purposely exposed myself after the shots have been fired to see what would be the effect on myself, and my experience is that it is very little, if any, different to gunpowder. I know it is a fact that some of the workmen say it makes their throat sore, gives them a headache, and that sort of thing, whilst others say they would sooner go into roburite smoke than gunpowder smoke. There is a great deal of difference of opinion amongst the workmen about it.

Mr. W. Bryham, jun., said his reason for asking the question was because he had had some little experience of roburite. They had fired something like 4,000 shots in their mines and they had never had a single complaint from the men, the firemen, or anyone else with reference to the fumes. The drilling of the holes with machine drills was also better done than by the hand drill. They had not had a single blown out shot or perceived any sparks or

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flame. He had every confidence so far that roburite was superior to gunpowder.

Mr. C. Cookson said he had not seen the experiments of Mr. Grundy illustrated before, and he agreed they were an argument in favour of the use of roburite. He personally did not think it could happen in practice that the amount of heat set up by the compression of air could be great enough to ignite gunpowder or touch-paper, but if that could happen, Roburite would be perfectly safe, because the detonator was so deeply buried in the roburite itself as to be protected from the heat caused by the compression of air. They had had in that district within the last few years several accidents by which men had lost their lives through ignitions of gunpowder which had not been clearly explained. The use of iron and copper stemmers had caused premature explosions of gunpowder, and on this account we have a strong argument in favour of the practical use of roburite or some similar safe explosive. For six or seven months they had used, to the entire exclusion of powder, Roburite in the Wigan four feet and six feet mines both for coal, roofing, tunnelling, and sinking work. With the exception of using powder in some of their sinking operations, they had used Roburite exclusively, and his opinion was that in coal, roburite was from 2¼ to 3¼ times the strength of compressed powder. In metal, its strength was considerably greater—three or four times—than compressed powder. At this colliery the shot-lighters alone fired the shots, and there were only five men who had anything to do with the roburite. Those men were the same they had had seven months ago, and they said they had no fault to find with it, no difficulty in handling it, and they had experienced no ill effects from the fumes. The colliers, officials, and himself were thoroughly satisfied with the work that was done. His personal observations led him to say that roburite

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brought down the coal in as good a condition as gunpowder did. He was perfectly satisfied with the use of it, and believed it to be the best, the cheapest, and the safest explosive extant.

Mr. HILTON said he had not had any experience of tonite, but he was told it was liable to commence burning whilst being charged. It was a powerful explosive, he believed, and there was no fault to find with its work.

Mr. WATTS said his experience of tonite did not confirm Mr. Hilton's observations. They had used tonite and gunpowder in driving 500 or 600 yards of tunnel, and he had not had any experience or complaints of any shots burning or of any mishap whatever.

Mr. HALL said that knowing the importance of the question of explosives he had watched the experiments made in this part of the county, and he had taken the opportunity of going about and questioning the colliers as to their experience of roburite. The conclusion he had come to was, that so far as fumes were concerned there was no danger, or that they were not at any rate worse than those of gunpowder. If a place was badly ventilated the fumes might be difficult to manage, but if there was good ventilation they would do no harm. With regard to the handling of roburite, he found there were cases where it had made the men very ill indeed. He had a letter from a doctor in this neighbourhood who said he had two serious cases on his hands, where men had handled the roburite, perhaps taken their dinner afterwards, and so got poisoned. Only a day or two ago he was down a pit and questioned the men about roburite, and they said they liked it as well as gunpowder, that it got the coal equally as well, and that they did not suffer from the fumes. It had been suggested at that meeting that roburite might be used in places where there was gas.

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He did not think that would either be legal or safe—because it had been stated in the paper before the meeting, that roburite had been seen to give off something like a red flash. If that were so, he did not believe any colliery manager would think of using it where there was gas. As regards safety, there could be no question that roburite was far safer than gunpowder, but he did not think it ought to be used or would be used where there was gas.

Mr. Barrett said Mr. Hall had mentioned two cases in which men had been damaged by the use of roburite. He had no practical knowledge of it, but he understood it was put in cartridges, and how could the men come in contact with the material? If it was a want of attention on the part of the men some means might be used to prevent it coming at all in contact with the human body.

Mr. Fletcher said it had been conclusively shown by Mr. Galloway and Messrs. Atkinson that great explosions had been due to firing the coal dust in the main airways where gas could not have been present. If, therefore, explosives were not to be depended upon, that emitted sparks, they were not to be trusted to without the same precautions as had to be used with gunpowder, and, if there was danger of producing blood poisoning, they were not lightly to be indulged in at all.

Mr. C. F. Clark said, in reply to Mr. Barrett's question, that if any workmen had been poisoned by the handling of roburite, it must have been from carelessness. The collier did not handle it at all in their pits. It was carried in cartridges or tin cases, and the shot-lighter who charged the hole fired the shot. The collier had nothing to do with it. The men who used it were practical men, and knew that under no circumstances were they to allow it to come in contact

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with their hands or bodies, for they might absorb it into their system if their hands were in a sweaty state. He had been told that a man had bit the end of a cartridge off with his teeth, that another had stuck his finger into a cartridge for the purpose of inserting the detonator, and then went and ate his food, and in those cases they could understand how they got poisoned.

The PRESIDENT said this question had been one of the chief things dealt with by Parliament last session, and he was glad to see that, whilst every scientific invention for the general benefit was well investigated in the colliery world, the importance of properly ventilating the mines was well looked after. They had had a very pleasant meeting, and he was glad that this, his first visit to Wigan in his present occupation of the office of the head of the society, had been so enjoyable and successful.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XX. SESSION 1888-9.

EVENING MEETING AT THE OWENS COLLEGE.

A SPECIAL EVENING MEETING of the Members of the Society took place at the Owens College, on Tuesday, the 29th January, 1889. The Museum block was thrown open for inspection, and refreshments were provided in one of the galleries of the Museum for the Members and their friends.

After refreshments had been served, the Members adjourned to one of the Lecture Theatres in the Beyer Buildings,

The President, Mr. Alderman JOHN KNOWLES, M.Inst.C.E., taking the Chair.

In introducing the business of the meeting,

The PRESIDENT said: I feel confident that it is a great pleasure to all the members to have this opportunity of meeting again in the Owens College, to inspect the admirable geological collection, in which this Society has an especial interest. I am sure, looking round the building, the arrangement of the collection is all that could be desired, and its being open to the public affords an opportunity not to students alone, but to everyone interested in geology, to

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come here and see what is being so admirably done by the curator, Professor Boyd Dawkins. You will all be pleased to see here Mr. Leader Williams, the Chief Engineer of the Manchester Ship Canal, and to find that he has brought some specimens for us. These, no doubt, will be very interesting. You will all recollect the pleasure we had during the last summer of going over a portion of the canal works, that from Warburton to Lymm, and though unfortunately Mr. Williams could not join us, the excursion was a most agreeable and instructive one. I hope we may have such another during the coming summer. There are some sections of that canal which the members should not by any means lose the opportunity of seeing. I have now much pleasure in asking Mr. Williams to say a few words.

Mr. Leader Williams said: I would advise any member of the Geological Society who wishes to see the very interesting stratifications and faults, in the series of marls so well known, near Warburton, to visit the cutting without delay. I regret exceedingly that, on the occasion of the Society's visit, last summer, I was called away and prevented from meeting you; but I look forward to another visit from you this year, when I shall be able to go with you to visit the red sandstone series lower down. In the meantime, if any member will address a note to me at my office—at the Ship Canal office, in Deansgate—I shall be pleased to give him a pass which will enable him to visit any part of the works. I would particularly advise you to see the Warburton section. The grey marl is beautifully developed in the red marl beds, and the faults are wonderfully brought out. I am having them photographed, and I hope to present some photographs to the Owens College Museum,—but the weather, lately, has been very bad for photography, and during rains the soil from the upper beds gets washed down, causing the beautiful markings to be obliterated. In

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the sandstone cutting, near Hulme's Bridge lock, and that near Millbank lock, we find interesting water-ripple marks in the rock. I have brought three specimens here—which I shall have pleasure in presenting to the Museum—from the Runcorn quarries. These are much finer than any yet found in the line of the Canal. Two of the blocks are of peculiar interest, they exhibit the footmarks of the Cheirotherium, the marks of the feet being unusually large and fine. In the Ship Canal excavations we are now passing through the same sort of stratification, and may expect to meet with similar remains to those now exhibited. When I was connected with the Weaver Navigation, some 14 years ago, a workman who was quarrying stone at Runcorn told me he had found a fossil woman. I asked if he had found her head?—"No." Her legs?—"No." What then? He had found her breasts. Here is the specimen in question. I need hardly say that the man was in error. The specimen, however, is unique. I regret to say that a part of the stone, and one which I should like to have preserved, was destroyed. The so-called "breasts" were two large worm casts, and the stone bore amongst its ripple markings, traces of large annelids, made as you may see at any time in the sands upon our coasts. I have shown them to many geologists—both members of the London Society and of this—and all have said that they never saw specimens so perfect as these are. Now, speaking of the Ship Canal Works, I noticed yesterday, in walking through a deep sand cutting near Irlam, 20ft. below the surface, and extending, as far as I could gather, over an area of about 30 square yards, a black vein, with 20ft. of white sand above, right through the cutting. I set about trying to ascertain what it was and I found that it was a compact mass of leaves—mostly, I think, of poplar, though I will not be absolutely positive on that point. I have a portion of the

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mass here. You will see that, when separated, it breaks up into layers. The leaf markings, in many cases, are quite perfect. I can give no clue, of course, to the age of this deposit. I have shown it to many gentlemen, including Lord Egerton, and his lordship was much interested in it and declared it to be the oldest piece of ensilage he had ever seen. It seems to me that at some far distant period, when the river flowed in another channel, somewhat distant from the present one, there was an eddy produced by some projecting substance which carried the leaves, as they floated down the stream, to be deposited in an extended layer. Then a flood came and covered them with a layer of sand. It is the most interesting deposit I have seen in connection with fresh water estuaries. In our Ship Canal Works nothing has yet been met with in the shape of ancient canoes,* or other relics of a barbarous age. The only relic we have found is the upper stone of a primitive corn mill—of which a photograph is exhibited. This was found 17 feet below the surface in the Salt Eye cutting at Barton; and I dare say if the Secretary were to write to the Directors of the Company they would be willing to hand this over to you, also, for the Museum. It is the only object we have found, as yet, carrying us back to the old inhabitants of this country. I hope, however, as the work progresses, that we may be able to make other discoveries.

Prof. Boyd Dawkins moved a vote of thanks to Mr. Leader Williams, and expressed the hope that they might not only have the pleasure—as they had now—of accepting specimens from him for the Museum, but also of more frequently seeing him take part in the proceedings of the Society.

Mr. Stirrup, in seconding the motion, said they had not only to thank Mr. Leader Williams for his present contri-

* One has since been found.

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bution, but also for the readiness with which he acceded to the request of the Society made through him (Mr. Stirrup) that the members might be permitted to visit the works of the Ship Canal. They might also, he believed thank Mr. Williams for favours to come, as he believed they would, through his kindness, have another opportunity, during the coming spring or summer, of again visiting those works. There was another favour he was hoping the Society would have at Mr. Williams's hands—that was a paper, which could not fail to be both interesting and valuable, upon the character of the works, and the sections passed through during the operations upon that great undertaking (the Manchester Ship Canal). Certainly, he thought there could be no better place for the reading of such a paper by Mr. Williams than at a meeting of the Manchester Geological Society, and no better place for its permanent preservation than the Transactions of that Society.

The PRESIDENT put the resolution to the meeting, and it was carried unanimously.

Mr. WILLIAMS briefly acknowledged the compliment, and said he hoped to earn the gratitude of the Society in a better way hereafter. He much regretted that, owing to the pressure of his professional duties, he was unable to attend the Society's meetings more frequently.

Professor BOYD DAWKINS, who was next called upon by the President, said he did not propose to detain the meeting more than a few minutes, and that in regard to matters which were to a large extent formal; but he thought, seeing that the Geological Society was really one of the important founders of the Geological part, at least, of that Museum, the members might be interested to know what additions had been made to the collections, whether by gift or purchase, since last they met in that building. He had, therefore,

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prepared a short list of the recent additions to the Museum. He must tell them, however, that it did not cover all. It merely represented those which had been given to the College by various benefactors in the interval between the two meetings:— .

Additions to the Geological collections of the Manchester Museum during the year ending 29th January, 1889:—

MINERALS.

Various specimens.—*From Dr. Girling.*
Seven Minerals from Laxey.—*From W. H. Rowe.*
Onyx and Crocidolite.—*From H. M. Ormerod.*
Silver Ores from Mexico.—*From C. Wehner.*
Artificially crystallised Bismuth.—*From J. Taylor.*
Wad, Barytes, Galena, &c., from Winster.—*From G. Wild.*
Copper Ores from Langness.—*From J. Lace.*
Salt from Manchester, 4ft. seam, Dukinfield.—*From H. Worrell.*
Calcites from the Stank Mine.—*Purchased.*

PRIMARY FOSSILS, &C.

A large Slab of Coal Measures Sandstone, with tracks of crustaceans.—*From H. M. Ormerod.*
A Fossil Tree, from Shaw Cross Colliery, Dewsbury.—*From Messrs. Crawshaw and Warburton.*
Specimens of Michelinia Grandis.—*From F. Worrall.*
Posidonomya Becheri.—*From W. A. Rogerson.*
Anthracosia, Middle Coal Measures, Hindley.—*From John Jones.*
Sigillaria.—*From Miles Settle.*
Sections of Corals.—*Purchased.*
Silurian Fossils from Lake St. John.—*From H. Bragg.*
Quartzite Boulder and Slickenside, from Wigan, 6ft. seam.—*From H. Cowburn.*
Ferns.—*From H. Bramall.*

SECONDARY FOSSILS, &C.

Six Liassic Specimens.—*From H. M. Ormerod.*
Pebble-bed Conglomerate.—*From J. Leader Williams.*
Vanadium Ores, &c., from Alderley Edge.—*From C. Roeder.*
Ripple-marked Sandstone Footprints of Cheirotherium from Runcorn.—*From J. Leader Williams*

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TERTIARY FOSSILS &c.

A large collection of Meiocene Fossils, from the Vienna Basin.—*From Prof. Neumayr.*

Eocene and Meiocene Fossils.—*From Prof. W. C. Williamson, F.R.S.*

St. Erth Pleiocene Fossils.—*From P. F. Kendall.*

Eocene, Meiocene, Pleiocene, and Pleistocene Fossils.—*From A. W. Waters.*

Cerithium giganteum from Paris Basin.—*From Mark Stirrup.*

Scutes of Glyptodon.—*From Liverpool Museum.*

A collection of Tertiary Fossils.—*Anonymous.*

Three Sculptured Stones.—*From Alex. Taylor.*

Collection of Native Weapons, from Queensland.—*From J. Lamond.*

Three Mummies.—*From J. Haworth.*

Four Stone Axes.—*From R. Greenhalgh.*

Six Stone Implements.—*From John Evans.*

MISCELLANEOUS.

A view of the Grand Canon of the Colorado.—*From Prof. W. Boyd Dawkins.*

Professor DAWKINS concluded by expressing a hope that, in the course of a few years, they might see the Owens College Museum—which, he said, had had a not altogether uneventful history—fully equipped, and among the most perfectly fitted-up museums in this country. In the nature of things, of course, it could not be a very large museum; but they purposed making it one of the most efficient museums possible for the teaching of this great population, in the midst of which it is situated, all those things which were taking place in the world before history began. He would not detain the meeting further, for the *pièce de résistance* had yet to come—that was Mr. Kendall's paper on the extinct volcanoes of Mull.

Mr. STIRRUP said: Before Mr. Kendall begins his paper, I should like to mention that one of the members (Mr. Cowburn) has brought for exhibition this evening one of

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those curious boulders found in the coal seams, which have been the subject of interesting debates at former meetings.

Mr. COWBURN explained that the boulder was taken from the Wigan 6ft. Seam, and added that he should have pleasure in leaving the specimen for the Museum.

Professor BOYD DAWKINS said the College would be much obliged to him for the gift.

Mr. STIRRUP said Mr. Cowburn had also brought down a piece of slickensides, curiously marked, and very interesting, also from the Coal Measures. They had also a fossil fern from the Pendleton collieries, brought by Mr. Bramall, which was very well preserved. The bringing of these specimens showed that the members were taking an interest in the Museum, and he thought that many of the members, by a little attention and good-will, might considerably add to the collections, and thus increase their interest, not only to themselves, but also to the public generally.

Mr. PERCY F. KENDALL, Assistant Lecturer on Geology at Owens College, then read a paper on "The Volcanic Phenomena of the Island of Mull," with lantern illustrations.

THE VOLCANIC PHENOMENA OF MULL.

BY MR. PERCY F. KENDALL.

A particular interest attaches to the study of regions in which volcanic activity has been in operation during the earlier parts of the Tertiary period from the perfection in which we may see exhibited in such districts the evidences of some of the phenomena connected with the *subterranean* operations of the now extinct volcanoes.

Reasoning by analogy from a large number of observations of a like nature, it becomes possible to form a tolerably clear

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idea of the conditions prevailing in deep-seated foci of the volcanoes which are active at the present time.

Our knowledge of the products of existing centres of volcanicity is limited to those materials which have been erupted at the surface such as lavas, ashes, and fragments of rock torn from below, with, in a few cases, rocks which have been injected from below into fissures rising up to, or near, the surfaces. In old and much denuded volcanoes, like the one I am about to describe, we are able to see much more and to make observations upon all these and also upon the rocks which have been formed and cooled far down beneath the surface, to see the effects which they have produced upon the adjacent rocks and the relations which they bear to them and to one another. We are enabled too to study with admirable facility the sequence of eruption of materials of different composition, and thus to obtain a clearer idea of some of the more recondite questions of the causes to which volcanic action is traceable, and the condition of the earth's interior.

The region now represented on our maps as the island of Mull appears to have been in early Tertiary times an undulating country, not very hilly, forming an integral part of the Highlands of Scotland, and probably not far removed from the coast line. It was composed of a truly remarkable diversity of geological formations, including the Archæan Gneisses and Schists, Coal measures, Poikilitic, Liassic, Oolitic, Neocomian, and Cretaceous strata. In addition to these, extensive tracts of the country were occupied by granite, lavas and ashes, representing a volcanic outburst possibly of Old Red Sandstone or Carboniferous age.

The present aspect of the island is one of remarkable beauty, though wild and rugged. The coastline is for the most part very precipitous, in places presenting mural cliffs

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rising to an altitude of upwards of a thousand feet. These great cliffs are mainly constituted of sheets of Basaltic lava piled one upon another, and resting on the stratified rocks already mentioned. Inland the northern half of Mull presents a succession of terraced hills (with one single exception, to be mentioned in the sequel) composed of Basalt; but in the south, besides these basic lavas (containing less than 55 per cent. of Silica), acid lavas are present, forming a ring in the centre of which rises a succession of great hills composed of granite and Gabbro (the former an acid and the latter a basic rock), both being composed entirely of crystalline material, a point of difference between them and the lavas. Passing indifferently through all the rocks of the island is a vast series of intrusive dykes and sheets, for the most part of basic composition. These are the broad outlines of the geology of Mull upon which all geologists are agreed, and I have now to present the interpretations which have been essayed in recent years by Professors Judd and Geikie and Mr. Starkie-Gardner, and to venture upon a discussion of their several views with the aid of the data furnished in published papers and in my own notebook.

Professor Judd, in a paper read before the Geological Society in 1872,* gave the first detailed description of the geology of Mull, and according to his view the lavas were poured out from a central cone of a magnitude rivalling that of Etna and intermingled in due proportion were ashes and agglomerates. He further expressed the opinion that the earlier eruptions were of acid materials, and that at a later stage basic lavas (Basalts, &c.,) were extruded, which flowed over and beyond the lavas of the first stage. This sequence was held to be indicated by the fact that the basic lavas were always superior in position to the acid, and that the

* Q. J. G. S., Vol. XXX.

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granitic core of the island, which Professor Judd regards as the source of the more siliceous ejecta, was broken into by great intrusive masses of Gabbro, which, upon his view, gave origin to the Basalts. From the way in which certain of the sheets dip in towards the centre, Professor Judd concluded that the focus of eruption had subsided, as so commonly happens with expiring volcanoes.

Professor A. Geikie traverses every one of these conclusions* and maintains that: 1. There was no central cone or crater, but that the Basalts were produced by fissure eruptions taking place, without any violent explosive action. 2. That the order of eruption was, 1st Basic, 2nd Acid, and 3rd perhaps Basic again, but the great Basaltic sheets were the products of the early eruptions.

Mr. Starkie Gardner's views conflict with those of both the great observers quoted above. With Professor Judd he agrees in considering that the acid stage was the first, but considers that it may have belonged to any period *precedent* to the Eocene, and he suggests that the granites of central Mull may be of the same age as those of the Ross. On the other hand he agrees with Professor Geikie in considering the Basalts to have been poured out from fissures, and not from any regular vent.

In endeavouring to place the arguments for and against each interpretation before you, it will be convenient if I deal with the subject under three headings:—

Firstly. What was the order of succession of the different materials?

Secondly. Of what character were the eruptions?

Thirdly. At what geological period did the events transpire?

"*Nature*," 1880, p. 3, and Trans. Ed. Roy. Soc. Vol. XXXV., Part 2.

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I must remark that an adequate discussion of these subjects is greatly impeded by the fact that the latest contribution to the subject by Professor Judd will not be printed for about two months.

As to the order of succession:—

Professor Judd has recently admitted that in his first paper he included under the generic appellation Felsites (for acid eruptive rocks) some Augite-Andesites, and even a few Basalts, so that the issue is narrowed to the question whether the great Plateau-basalts preceded or succeeded the true acid lavas.

Professor Judd mainly relies upon his observations, which appeared to show, *a*, that the Basalts are always superposed upon the acid lavas, *b*, and that the Basic rocks, such as Gabbros are intrusive in the acid series, and *c*, that in the agglomerates associated with Felsites no fragments of Basalt are found.

Professor Geikie, on the other hand, maintains that the superposition of the basic on the acid rocks is a case of deceptive superposition, and that the acid rocks are intrusive, and that similarly the masses of Gabbro were really afloat upon the Felsites and Granophyres.

Great weight undoubtedly should attach to the opinion of so eminent a geologist as Professor Geikie, and certainly his explanation would remove several difficulties, such for instance as the case observed by the writer, in which Granophyre is clearly *intrusive* in a rock which, to microscopic examination, presents all the appearances of a typical Rhyolite, but which, under the microscope is at once recognisable as a basic rock. In view of Professor Judd's qualification of his original statement as to the inclusion of Basalts in the earlier products of eruption, this fact loses much of its importance. The reliance of the Director-

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General upon the analogy of the Scuir of Eigg, in which Pitchstone has unquestionably flowed down a valley excavated in Basalts, appears a rather unsafe argument, for we know that at the same time that Vesuvius and Stromboli were passing through a basic stage the adjacent volcanoes of Ischia and Vulcano were pouring out acid lavas.

One fact which appears to have been lost sight of in this controversy has weighed very strongly with the writer in forming an opinion on this very difficult subject. It is, that in an appendix by Mr. Grenville A. J. Cole to a paper by Mr. Starkie-Gardner on the leaf-beds, a description is given of the pebbles composing a river gravel lying almost at the base of the Plateau-basalts, and amongst other rocks occurring as pebbles is Sanidine Trachyte, a lava of decidedly acid composition. This rock contains fresh and unaltered Felspar, and therefore could not belong to the Palæozoic lavas, consequently the conclusion is almost inevitable that they were fragments of the acid lava flows of the Tertiary period, which therefore must be held to have preceded the Plateau-basalts. In a quarry where the Granophyre is worked at Toll Doire Salen, I found a small string of Basalt occurring as an intrusion in the Granophyre. The bearing of this fact is sufficiently obvious to need no further comment. The much wider question raised by Professor Geikie regarding the mode of eruption of the Plateau-basalts can only be dealt with by a mere balancing of probabilities. Professor Judd regards them as lava streams which have flowed from volcanic craters of the normal type, whereas Professor Geikie considered that they were poured out from a series of great rents in the earth's crust, and in an article in *Nature* he remarked "Nor, so long as the incubus of 'cones and craters' lies upon one's mind, does the question '[of the origin of the Hebridean dykes]' admit of an answer."

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Dr. Geikie cites the following facts in support of his contention:—

1. That the successive sheets do not thin out as they are traced away from the supposed centres.

2. Ashes and agglomerates are not present in the proportion which might be expected if the materials had been poured out from an ordinary volcanic vent.

He further institutes a comparison between the Mull lavas and the great lava sheets of the Snake River, Idaho, the study of which first led him to conclude that the Hebridean flows were of the nature of "*Fissure-eruptions.*"

Professor Green, in an article in "*Nature,*" a most valuable contribution to the discussion, points out that "Fissure-eruptions" are purely hypothetical at present, as we are acquainted with no modern examples of volcanic action, and hence they should be looked quite as a *dernier ressort;* and he further draws an interesting parallel between the Hebridean volcanic system and the Hawaiian volcanoes. The study of the latter lead Captain Dutton, of the U.S. Geological Survey, to withdraw his adhesion to the Fissure-eruption explanation of the Snake River phenomena, and the majority—if not the whole—of his colleagues, including Mr. Clarence King and Dr. Hayden, have experienced a similar change of opinion, as pointed out by Professor Judd in his last paper to the Geological Society of London; so that Dr. Geikie is in the singular position of appealing for proof of Fissure-eruptions in Scotland, to a case which the most competent observers on the spot consider to be referable to the category of ordinary volcanic manifestations.

The Island of Hawaii contains several craters, but the eruptions of lava more commonly proceed from openings torn in the lower slopes, and these eruptions, though occasionally taking the form of fountains of molten rock,

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are, as a rule, not of an explosive character, and consequently, ashes and agglomerates—as in Mull—are infrequent.

On account of the eruptions so rarely taking place from the craters, and still more from the extreme fluidity of the lavas, by virtue of which they flow to great distances, the average slope of the island is only about 5°, we may conclude that the lava streams would not show any very marked thickening when they were traced towards the centre of the island. This, as I have already stated, is a peculiarity alleged by Professor Geikie as characterising the Hebridean basalts, but I must remark that my experience in Mull leads me to entertain grave doubts of the possibility of tracing the streams there for a sufficient distance to enable any definite conclusion upon the point to be arrived at.

Prof. Geikie observes regarding the dykes systems of the Hebrides that there are apparently two sets, one consisting of enormous masses persistent over a great extent of country, and which he considers to have been the feeders from which the Plateau-basalts flowed, and another set forming a plexus of innumerable small dykes, having a general N.W. and S.E. trend. He further remarks that the dykes have run a resistless course through rocks of very variable character. My own observations have been of a minute character only in the neighbourhood of Salen, in Mull, but I have not found any traces there of the large dykes to which he alludes, and as to the smaller dykes of which I have observed some hundreds I can only say that the directions which I measured appear to indicate that they radiate from the centre of the southern half of the island. These small dykes seemed to me, in one case at least, to be incapable of pursuing such an undeviating course as Prof. Geikie claims. At Gribund, on Loch na Keal, I found that Basalts were seamed with dykes at short intervals, but along the shore, where Gneisses are exposed beneath the cretaceous rocks

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which immediately underlie the Basalts, in the course of half a mile I found but a single dyke. I should imagine that the disruptive forces were incompetent to tear a passage through such stubborn rocks, and had to seek relief by means of *horizontal* rents for I found a thick intrusive sheet at, and near, the village of Gribun injected along a line of parting at the base of the bedded basalts. There is one exceptional phase of volcanic activity in Mull to which I alluded at the outset. About three miles from Tobermory in the midst of a basalt country rises a rugged hill with a crateriform hollow on the top which is occupied by a small tarn called Sarsta-pol. This hill has been shown by Prof. Judd to be the denuded wreck of a small *puy*, and the tarn occupies the site of the old crater though of course its present form bears only an indirect relation to the original shape of the volcano and its crater. The central portion is the neck by which molten material was conveyed to the surface, and the ring-like hill is composed of basalt greatly altered by the flow of highly-heated rock within. The rock occupying the neck is a Dolerite of exceedingly beautiful structure, and it represents a residual mass of basic material which remained within after the decline of the volcanic energy, and which cooled so slowly as to permit of the nearly complete crystallisation of its constituents.

The age of the Mull lavas can be approximately determined by the fact that they overlie the upper chalk and include near their base the celebrated leaf-beds, which are regarded by Mr. Starkie Gardner as of Lower Eocene or possibly Pre-Eocene age. Whether any of the lavas are of later date than Eocene cannot at present be determined, but I think it highly probable that the volcanic activity was continued into Oligocene or even later times.

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[Note.—The publication of Prof. A. Geikie's magnificent memoir subsequently to the reading of this communication enables me to modify and correct certain remarks in which I have scarcely done justice to the case so ably presented by him, being misled by the imperfections of the abstract. The Sanidine-Trachyte pebbles of Ardtun *are* duly noted by him and are ascribed to deep-seated masses of acid material which he supposes to have consolidated at an early period, and to have yielded a portion of the fragmental ejecta accompanying the basic lavas. This explanation appears to me to be very unsatisfactory, and to be one of the few weak points in a paper upon the main conclusions of which I feel great difficulty in suspending my judgment until the appearance of Prof. Judd's reply. Dr. Geikie denies the existence in Mull of any acid lava-sheets whatever, and attributes the whole of the acid rocks of the island to intrusions posterior in age to the Gabbros, but anterior to the series of small basaltic dykes. The evidence which he adduces in support of his opinion is very strong.

As to the character of the eruptions to which the Plateau-basalts are attributable—though Dr. Geikie furnishes plenty of examples of volcanic necks which might have furnished the necessary channels for the conveyance of the lavas to the surface, yet he cannot point to a single case in which any connection can be traced between them and the adjacent lavas. A further defect of evidence is noticeable in the failure to connect in a solitary instance, a lava stream with a dyke. This relationship appears to me to be demanded by the hypothesis of fissure eruptions, and the inability to produce such evidence, certainly cannot be attributed to the lack of good sections, for, in the great cliffs and precipices which form so striking a feature in the volcanic region extending from Ireland to Skye, thousands of lava-sheets, and tens of thousands of dykes are admirably exposed.

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Until some such cases can be cited, I think it behoves all enquirers to practice the same forbearance which I have imposed upon myself, and to accept the fascinating hypothesis of Dr. Geikie, if at all, merely tentatively, and then only after studying Professor Judd's forthcoming counter-blast.]

At the close of the lecture, a lantern exhibition was given of a series of photographic slides illustrative of the rock scenery of Mull. The views were most effectively rendered, the lantern being kindly manipulated by Mr. Leech.

The members then adjourned to the galleries of the Museum, under the guidance of Professor Dawkins and his assistants, where special exhibits were pointed out and commented upon, thus bringing to a conclusion a very interesting meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, February 12th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

JOSEPH DICKINSON, Esq., F.G.S.,

(in the absence of the President) occupied the Chair.

NEW MEMBER.

Mr. OSWALD R. SWETE, electrician, Crown Works, Lambeth, was balloted for and duly elected an ordinary member of the Society.

The CHAIRMAN said: Some of you may have heard that since our last meeting we have lost one of our leading members (Mr. Radcliffe), who has been a colliery manager in this county (at Ashton-under-Lyne and Dukinfield) for many years. Mr. Radcliffe caught a chill a few weeks ago, from the effects of which he died in a few days. His loss will be deeply regretted by the members of this Society.

Mr. STIRRUP said he thought it would be in accordance with the feelings of the members, and most appropriate at

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this, the first meeting since Mr. Radcliffe's death, to pass a vote of condolence with the widow and family of the deceased gentleman. Mr. Radcliffe, he added, was a valuable member of the Council and took an active interest in the work of the Society, and he was not aware of his decease until he came into that building. He was much shocked to hear of it.

The motion that a resolution of condolence on their bereavement should be sent to Mrs. Radcliffe and family, moved by Mr. Stirrup and seconded by Mr. Hindley, was carried unanimously.

THE SALT WORKS AT HALE, IN LANCASHIRE.

Mr. STIRRUP stated that Mr. Charles Roeder, some little time ago, sent him a communication he had received from Mr. Ward, of Northwich, which, taken in connection with previous papers and discussions in the Society's Transactions on the salt manufacture and industry, was of considerable interest. The remarks in the present communication were historical, and were addressed to Mr. Roeder by Mr. Ward, in answer to some inquiries the former had made with regard to the meaning of the following extract from J. Berry's "Lancashire Journal," Manchester, 25th August, 1740:—

"To be lett for any number of years and entered on "immediately:

"A *Salt Work* for the Refining of *Rock Salt*, containing "4 Salt Pans with all other Conveniencies for Working the "same, with a good Winter Stock of Coals laid down, at "*Dungeon* in the County of Lancashire upon the River "Mersey, six Miles from Liverpool, four Miles from the "Coalpit.

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"Further Particulars may be had from the Clark of the "said Works."

Mr. Ward wrote:—

Brookfield House, Northwich,
November 24th, 1888.

Dear Sir,—Many thanks for your very interesting letter *re* the Dungeon Salt Works.

I can enlighten you a little on the matter. The six miles from Liverpool has probably misled you. If you will refer to any Ordnance Map you will find that on the Lancashire shore of the Mersey, near to Hale Head, there is a bight, and on this bight some salt works were situated up to about 40 years ago. I have had a man working for me who worked at them. They were in the occupation of Ashton & Blackburne (the Blackburne's of Hale), of Liverpool. They were as described, refiners. There were works at Frodsham, just opposite, that were of the same character. The process was the same as is still carried on at Drogheda and a few other places along the coast. Rock salt is brought from the Cheshire mines and put into a large reservoir. As soon as the tide makes, the salt water is allowed to fill the reservoirs; at the turn of the tide the gates of the reservoirs are closed. The water dissolves the salt and makes a strong brine; this is evaporated in the usual way and salt made. By utilising the sea water the salt contained (about 2½ to 3 per cent.) is abstracted, and is so much to the good for the manufacturer. I do not know the origin of the name Dungeon, but you will find the bank on the Mersey opposite this place called Dungeon Bank, and the point to the westward of Hale Head, Dungeon Point.

Since salt has been made so cheaply in Cheshire the refineries have died out on the Mersey. I think there is not much doubt but that salt was made in this way at Liverpool, on the site of Salt House Dock, and within the last 25 years it has been so made by the firm of Ashton, Blackburne & Co., at Garston. The inferior or cheap rock salt, containing much clay, was used for these refineries.

The Frodsham, Dungeon, and Garston works have all been closed since salt could be made so cheaply from brine. All have been worked by men now living. The Dungeon works were frequently troubled by the shifting of the sand banks, so that at times there was little or no water for craft to reach the works. Recently the main

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deep has passed close in shore, and deep craft have passed within a stone's throw of the old works.

In 1740 the works could not have been very old. The Weaver was only made navigable (under the Act of 1721) about 1731-2, and very little rock salt could have been sent to these refineries, as in 1732 only about 9,000 tons were sent down the Weaver.

Thanking you for your courtesy in writing me,

I am, most sincerely yours,

Mr. Charles Roeder, Fallowfield. THOS. WARD.

P.S.—The Salt Works at Dungeon and Garston are marked on the 1-inch Ordnance Map, as are also the Frodsham Works.

A MEMBER stated that a part of the works referred to still existed; they were now used in the manufacture of a kind of patent stone, and situated at Hale Cliff—not Hale Head.

Mr. DE RANCE said he had seen both the works at Hale and those at Frodsham. The supposition of some people that rock salt had ever been found at either place was quite a mistake.

ON THE CAUSE OF EARTHQUAKES, OF THE DISLOCATION AND OVERLAPPING OF STRATA, AND OF SIMILAR PHENOMENA.

BY MR. THOMAS OLDHAM.

What I am going to speak to you about this afternoon is upon a subject that has caused very much perplexity and doubt in the minds of many of our most eminent geologists and scientists in endeavouring to account for the cause of four of the greatest phenomena in nature, that have taken place, and are still taking place over our globe; namely, the cause of earthquakes, the dislocation and overlapping of the strata, the submergence and upheaval of continents, and the different climatic epochs from glacial to tropical, that have occurred through all geological time.

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The hypothesis that I intend to submit to you is based upon purely physical laws, and I have often felt surprised that nobody has ever promulgated them before. In the first place, I must premise by stating that it is ascertained that this globe is about nine miles more in diameter at the equator than it is at the poles, and the cause of this I will explain presently. In the next place, it is known that the globe rotates on its axis about 26,000 miles every twenty-four hours, equal to a speed of 1,725 feet per second, or nearly equal to the flight of a cannon ball. Another thing that has been ascertained is, that the axis of the globe is gradually altering, or getting more oblique, and that it requires thirty-nine thousand years before this alteration arrives at its maximum.

My reason for bringing these matters before you is, that they have a considerable bearing upon the explanation I am about to give. When we take into consideration the great velocity with which the globe rotates, it is evident that a great amount of centrifugal force must be exerted, and as nature never does anything without a motive, it will be seen that centrifugal force is the cause of the globe being nine miles greater at the equator than it is at the poles.

It is well known that according to the law of physics, centrifugal force acts at right angles or perpendicular to the axis, and as the axis gets gradually more oblique, so will the direction of the equator. After having named these matters, I will now commence to explain first of all, the course of earthquakes, and the dislocation and over-lapping of the strata.

It is supposed that the crust of the earth is only about 15 or 16 miles in thickness, and below that distance the interior of the globe consists of a semifluid mass of incandescent minerals. We can judge of the thickness of the crust by the rise of temperature as we descend deep shafts

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particularly in coalpits. In sinking the first 1,000 feet the temperature will rise about three or four degrees, and so on, the deeper you go the more heat will be accelerated, and at the same ratio a depth of 15 or 16 miles would reach a temperature of over three thousand degrees, sufficient to fuse almost anything we have on this earth. In order to bring these matters more practically before you, I would suggest a model to be made to represent our globe, in exactly the same proportions as they now stand towards each other, under these conditions, and for this purpose I would take a mass of plastic matter such as potter's clay, of sufficient consistency to form it into perfect sphere of about nine feet in diameter, and pass an iron rod through it, supported on two pedestals, to one of these attach a pulley in connection with a small steam engine, but before putting it into motion, coat this sphere over with a crust of a more brittle nature, of the same relative thickness as the crust of the earth, and mark lines upon it to represent latitude and longitude, and also making that crust in six different colours to represent the different strata, and then when motion is communicated, and after it has attained a certain speed you will also find that centrifugal force will cause this sphere to project at the equator in the same way that ours does, and if you then gradually raise one end of the axis, say the one representing the south pole, the equator will get gradually more oblique, and move towards the north as in the eastern hemisphere, and south as in the western hemisphere; you will find that the crust will be riven and dislocated similar to what we see taking place in former ages on our earth. It is also known that centrifugal force acts not only at right angles to the axis, but it has also a lateral motion, which will account for the dislocation and overlapping of the strata. I must also remark that this cannot be a perfect model of our sphere for several obvious reasons, one of which is that at least two thirds of our globe is covered with water.

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It must also be borne in mind that although the difference of nine miles (which only means 4½ miles all round) does not appear to be very much in comparison to the nine thousand which the globe is in diameter, still you will find that even 4½ miles difference in our present levels will be found quite sufficient to submerge any continent on the face of the globe with the exception of the tops of mountains. Astronomers tell us that the deviation of the axis arrives at its maximum every 39 thousand years, consequently where the north pole now is the south pole will be when the next climax occurs, and during this period the climatic alterations will vary from glacial to tropical, in consequence of the equator always maintaining its position towards the direction of the sun.

It is supposed that our last great climax was a glacial one, and there are plenty of evidences to prove this, by the frequency with which moraines, and the effects of glaciers are met with in this and much more southern countries.

Even in the river Amazon, which is now directly on the equator, Agassiz found ample evidence of this by the numerous remains of glaciers and moraines which he met with on his exploring expeditions into those countries. In like manner, we can go to northern latitudes, such as Iceland, Greenland, and Siberia, and find any amount of fossil plants, which must have originally grown in a tropical climate; besides, there are innumerable remains of tropical animals, such as the elephant, mammoth, &c., and even at the present day, after a very heavy storm, numbers of elephant's trunks are washed up on the coast of Iceland, and in the deserts of Siberia numbers of the remains of elephants and mammoths are found with the hair and flesh still adhering in a frozen state. Even in England we find the remains of extinct animals that could only have existed in a tropical climate.

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It may perhaps be thought by some people that if these theories are correct we should already have some evidence to prove that our climate is getting warmer, or that the levels of the sea coast are altering; but when we take into consideration the infinitesmal duration of human life in comparison with the geological epochs, you will find that the age of man is little more than an atom, and even our historical records—such as we be able to place any reliance upon—go back only about 2,000 years, and beyond this it is only legendary for about 4,000 more, making altogether about 6,000 years, at which time it is stated that the whole earth was subjected to a universal flood. I think there are very few scientists of the present day who would argue that the water which caused this flood came from the clouds, but according to my theory it would be caused either through a depression or upheaval of some part of the earth's surface caused by the action of centrifugal force.

It is supposed, and I think with very little doubt, that at one period the places occupied by the Atlantic and Pacific Oceans were large continents, and when these came to be submerged a great portion of Africa and America became upheaved. Indeed the numerous islands and atolls in the Pacific Ocean clearly point that they are the remains of large continents, and when naturalists go up the mountains in both North and South America they find numbers of beautiful specimens in conchology which could only have got there by upheaval or being washed over by the ocean. There is another remarkable fact that I wish to call your attention to, namely that most of the land that is now above the ocean lies north of the equator, and we do not know but that Australia and New Guinea are not the remains of a large southern continent that existed at some prior epoch, and which, when the next great climax occurs, will be again brought into existence, although in a different form. I would also

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wish to call your attention to the earthquakes and disruptions that are taking place at the present time, as bearing out these theories; that in the east they occur north of the equator, as in China, Japan, &c.; and south of the equator as in Peru and Central America, and which in course of time will continue to diverge more to the north and south of the present equator. My reason for suggesting that lines should be drawn across this supposed model to represent latitude and longitude is for the purpose of showing the extent of those fractures and dislocations as they take place in the crust during upheaval, and no doubt you will find a great disparity in the magnitude that they assume, but they are just as likely to occur under the ocean as on land, and if in the former case, we are only made aware of it by immense tidal waves, such as have occurred when the coast of Peru subsided some few years ago, the influence of which was felt not only on the coasts of New Zealand and Australia but also on our own coasts.

Geologists have hitherto been very much perplexed in accounting for these great changes, and I will quote a short paragraph from an address given by our worthy Chairman on the 1st November last, in which he says: "These things "have undoubtedly been governed by some law, and appar- "ently we must look for some other origin than either "denudation by water for the formation of the main contours "and beyond ice to account for the formation of moraines "and drift."

Now this is just what I always thought myself, but if you will give these theories a little of your attention you will find they will amply account for all those denudations, abrasions and depositions that cause so much perplexity to geologists and other scientists at present.

I am quite prepared to find that many people may consider this hypothesis as chimerical, nevertheless we know

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that these things have occurred, and if any other person can devise a more probable elucidation, so much the better.

Before I conclude this address I should like to ask one question, but I do not expect that you will answer it this evening, although you may do so at some future meeting,—namely, from where and how is the power derived that causes this globe to rotate on its axis 26,000 miles every twenty-four hours?

In answering this question I expect that you will not allude to anything of a supernatural nature. This is a physical world, it is governed by natural laws, and the laws of nature are the laws of the Almighty.

The thanks of the meeting having been given to Mr. Oldham,

The CHAIRMAN said, he thought that the rate of increase of temperature, which was put at three to five degrees per 1,000 feet—

Mr. OLDHAM: That is merely nominal.

The CHAIRMAN continued: That was much lower than was found to be the case. Taking the normal temperature to be 50 degrees at a depth of 50 feet below the surface of the ground, the rate of increase had been placed at one degree for every succeeding 50 or 60 feet. This was borne out by a very large number of observations, and one degree for every 20 yards was now taken as the standard.

In the course of further conversation, the CHAIRMAN said: Mr. Oldham has spoken only of the centrifugal force caused by the rotating of the earth upon its axis, but there is another motion, the longitudinal motion round the sun—that motion which the late Dr. Brown, of Pendleton, in a paper by him which I read the other day, held to be the cause of gravity, the rotating of the earth upon its axis being a counteracting force.

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Mr. OLDHAM maintained that centrifugal force would counteract gravity.

The CHAIRMAN: That was exactly Dr. Brown's view. Dr. Brown showed that the centrifugal force was so great in the planet of Saturn that it was almost flying asunder, and that the rings of Saturn were to be attributed to it. There is another point in this paper which may be quite true, but it rather startled me. Mr. Oldham said that two-thirds of the surface of the earth were covered with water. I should have thought, off-hand and without going into a calculation, that they were pretty nearly equally divided, and that if there was apparently more sea than land the difference was made up by that of which at present we know nothing—the poles, for instance, where there is supposed to be land, not having yet been reached. Then there was an allusion to the flood. I did not quite catch whether Mr. Oldham meant the flood in the time of Noah; but if he did I must say that all scientists, so far as I know their views, are agreed that that flood was of a very much more local character than was supposed to be the case in those olden times, when there were not such ready means of intercommunication between the peoples of the world as now exist.

Mr. DE RANCE said the paper was one the discussion of which was somewhat difficult. It had a double aspect—astronomical and physical on the one side, and geological on the other. On the physical aspect he would not presume to speak, but he could not agree with the author of the paper that geologists were puzzled to account for the overlapping of strata, the formation of continents, for he believed that alteration in the thickness of the earth's crust had much to do with movements of upheaval and depression, as long ago pointed out by Herschell. Evidences of slow and gradual movements were to be seen in their own district, and, looking abroad, to the shores of Denmark and Sweden, they

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saw certain areas gradually subsiding, and certain other areas which were being upheaved; and his former chief on the Geological Survey, Sir Andrew Ramsay, well pointed out that when a continental area was gradually sinking, the waves of the sea exerted upon the edges of the coast line an effect which produced a "plane of marine denudation," the upper portion ceasing to be affected at the point at which subsidence stopped; and afterwards when that area, once a sea bottom, came to be tilted up—and rain fell on it, and rivers ran over it, valleys were formed—a section across such a continent, in a line from the mountain summits down to the sea, would show that no hill top exceeded in height the old "plane of marine denudation." The alteration of thickness or weight of the earth's crust was produced by denudation, subsidence of a curved surface produces flexures in the strata, while faults and fractures were the result of the re-elevation of that curved surface, in which the rocks have to expand, so as to fill a larger area. During a submergence land was washed away by the sea; and in process of time, subsidence was followed by upheaval, and the land assumed new outlines, rain and rivers doing their part. Underground temperature had been referred to, as the Chairman had stated the rate of increase below a certain level, is one degree in every 56 feet. This subject was very elaborately inquired into by a Committee of the British Association; they carried out experiments both in England and the continent—the records from the Mont Cenis tunnel being especially interesting. The curves of temperature corresponded roughly with the curves of undulation of the surface. Then, Mr. Oldham spoke also of overlapping, but he (Mr. De Rance) did not follow him; take the overlapping in the Permian formation in Lancashire, the Permians between Manchester and Tyldesley rested upon high coal measures, but north of Ormskirk they rested on the millstone grit.

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It was obvious that the strata were tilted up before the Permians were deposited, and that one particular rock might overlap five or fifteen or any number of strata. As to climate Mr. De Rance doubted that there had been a series of tropical or glacial climates, and pointed out that, looking at the geology of the Arctic Regions, so far as could be seen, climate, as now understood, was quite a modern innovation. We had in our own country, Dudley limestone fossils, which were identical with some found in Sweden and in the Arctic Regions, carboniferous limestone, liassic, and oolitic fossils, also occurred—identical not only as to the genera, but actually as to the species with those of Europe. In remote ages the same climatic conditions seemed to exist all over the earth's surface.

Mr. STIRRUP said the title of Mr. Oldham's paper was an ambitious one, suggesting the resolution of some of the difficult problems belonging to dynamical geology. To assign the varied phenomena treated of as all being due to one cause, was, he considered, hazardous in the extreme. Mr. De Rance had not, he thought, addressed himself to the real point in the paper, which was "the *cause* of earthquakes and of the dislocation and overlapping of strata," &c. Mr. Oldham assigned all to the action of what he called centrifugal force. The author had only given us, however, his own theoretical views, and had not attempted to prove by the evidence of a single example, how centrifugal force had acted in bringing about such great movements of the earth's crust as those he had referred to. He felt convinced that if Mr. Oldham had had a greater familiarity with practical geology, and also a wider acquaintance with geological literature, he would not have assigned the cause of all these phenomena to the action of the one force, which he termed centrifugal. Moreover, Mr. Oldham had not sufficiently explained what he meant by that

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force, and how, and in what way, earthquakes were produced by it, how it caused a dislocation and over-lapping of the strata, and the subsidence and elevation of continents, and all the other phenomena he included in the operation of this unique force. That was what they required him to do—he must give them fuller explanation upon those several points before any satisfactory discussion could take place. Although geologists differed in opinion as to the cause of earthquakes, and the elevation and subsidence of continents, they were, by general consent among geologists, assigned to very different causes from those which Mr. Oldham had placed before them. He hoped Mr. Oldham would enlighten the meeting on the full meaning of "centrifugal force" as understood by him, and its method of work in producing the physical phenomena he had discussed.

Mr. Oldham said: Mr. Stirrup evidently does not take into consideration what centrifugal force is capable of doing. If he will consider the supposed model I have named he can imagine the thing for himself. Supposing you take a mass of plastic matter—say potter's clay—and cause it to revolve (without putting any crust at all upon it), the mere motion upon its axis would cause it to bulge out at the middle.

Mr. De Rance asked if Mr. Oldham had had such a model made.

Mr. Oldham said he had not.

Mr. Tonge said he had, like Mr. Stirrup, been struck with the title of the paper—"The Cause of Earthquakes, &c." He followed the reading of it with some interest, and when Mr. Oldham sat down he thought he had scarcely got beyond the beginning of it. He quite expected Mr. Oldham to go on to show how very different the earth was to a plastic model. The earth, so far from being composed of dead matter, was to a large extent composed of matter—

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which, if not living matter, was at least in a state of great activity. He believed, according to the latest theory, that the earth was not so heavy as Mr. Oldham would have them suppose: it was partially composed of molten matter—only partially, however—and the hard crust at times exhibited rents, accompanied by earthquakes and giving rise to volcanoes; but this plastic model which they were asked to imagine would not be capable of any such upheavals from within—certainly nothing analagous to volcanoes. Such a model, therefore was not to be compared with what goes on on the earth's' surface. He (Mr. Tonge) was of opinion that water and heat had very much to do with earthquakes, and that these could not be all attributed to centrifugal force, which, as he understood Mr. Oldham, was a sort of rending the earth asunder by the speed at which it revolves.

Mr. Percy F. Kendall said he had not had the advantage of hearing the whole of the paper, but from what he had been able to gather, the author relied upon the action of a mass of clay rotating upon a potter's wheel as furnishing a parallel illustration to the action of the earth rotating in space. There was only one criticism which he could venture to offer to that view. Let the author make his model, and place upon its surface small bodies, as peas or sand grains, to represent the materials that were loosely strewn on the surface of the earth, and let him then rotate his model, and see how far the conditions were parallel. He would find that his peas, or sand grains, representing houses, churches, and human beings would be flung off. That simple experiment would doubtless suffice to convince Mr. Oldham that centrifugal action was not the key to the whole of these problems.

Some remarks were offered by one or two other gentlemen, and Mr. Oldham briefly replied.

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ON A LARGE BOULDER FOUND IN OXFORD STREET, MANCHESTER.

By Mr. Percy F. Kendall, Assistant Lecturer on Geology at the Owens College.

In a preliminary note upon this boulder,* which is now fixed on an artificial mound in the quadrangle of the Owens' College, Manchester *(see Fig. 2)*, I stated in general terms the main peculiarities presented by the erratic and its mode of occurrence. Professor W. Boyd Dawkins also contributed an article to the *Guardian* newspaper.† The object of the present communication is to give a more detailed account, to point out certain peculiarities which were not observed at first, and to correct one or two errors which have been made in the description of the beds in which the stone was embedded.

From the subjoined section (*Fig. 1*) it will be seen that, commencing at the top, after traversing a small quantity of made ground the shaft sunk for the extraction of the boulder passed through about 25 feet of tough boulder clay, containing numerous boulders of small size, mostly well-rounded and striated, beneath this came a bed of coarse gravel about 8 feet with many small boulders *all lying with their long axes horizontal*, and beneath this again came New Red Sandstone.

The great boulder lay with its long axis in a horizontal position, and directed about S. 18° E. Mag.,‡ and it was *completely enveloped* in boulder clay. Mr. Mellard Reade in a communication to the Liverpool Geological Society, describes a band of "Book-leaf clay" as occurring in the

* Proc. Lit. and Phil. Soc., Manchester, 1888.

† *Manchester Guardian*, March 2nd, 1888.

‡ This direction was taken from a long irregular scratch upon the (original) upper surface of the stone ("C" of sketch.)

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Trans. Man. Geo. Soc. Part VI. vol. XX.
To illustrate Mr. Percy F. Kendall's paper

FIG. 1.

Section showing position of the Boulder in the Glacial beds.

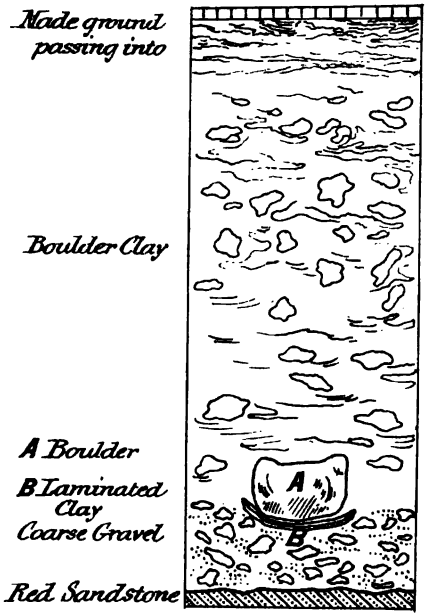
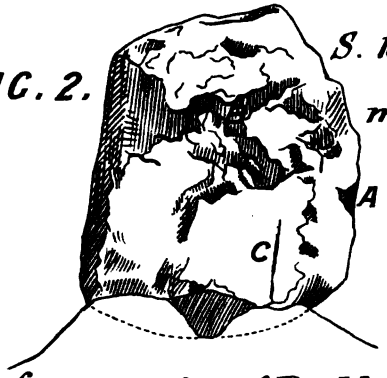


FIG. 2.



View of upper surface of Boulder.
A Scar of Fracture.
B Prominent Ridge from which the weathered crust has been scrubbed.
C Scratch by which the bearing was taken.

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gravel beneath the boulder, but I fear that the difficulty of making accurate observation by candle-light in a narrow cutting caused him to be misled. I examined the section many dozens of times but it was only a few days before the boulder was raised that I observed in company with Dr. Julius Cohen a singular circumstance that will explain the discrepancy between Mr. Reade's version of the section and my own. The boulder as I have stated was completely enveloped in boulder-clay, yet the bottom of the mass was 3 feet below the general level of the surface of the gravel-bed. It had in fact obviously been dropped down when a few feet at most of the clay had been deposited and by the violence of its descent had driven 3 or 4 inches before it down into a hollow impressed in the underlying gravel to a depth of 3 feet. The pellicle of clay carried down has no doubt owed its fine lamination to the pressure of the boulder. I could not detect any crushed or fractured stones in the underlying gravel.

Composition, &c.—In the note previously alluded to I characterised the rock as an andesite, being guided in my diagnosis chiefly by the microscopic characters and the sp. gr (about 2·74). In this opinion I am confirmed by an analysis kindly made for me by Dr. Cohen. From the figures given (*see page 145*) it will be seen that there is 63·6 per cent. of silica present and as triclinic felspar is predominant, the rock may be safely pronounced to be an andesite of somewhat acid composition.

For comparison I give an analysis of a rock from Coniston, which I recognised in the first instance as a Lake District rock solely by its resemblance to the rocks forming so large a percentage of our boulders. A reference to the catalogue furnished the locality "near Coniston." The microscopic characters of the rock are obscure and inconclusive on account of the great amount of decomposition which has

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taken place; but it may be stated that triclinic and orthoclose felspars have been detected, and much epidote of secondary origin and a finely crystallised ground mass.

I am favoured by Professor Dawkins with the use of a specimen and section of an andesitic rock of very similar character from Shoulthwaite, Cumberland, and a comparison with it and other Lake District lavas induces me to qualify my former opinion regarding the place of origin of the boulder and content myself with the vague and general localisation to the Lake District; at the same time my experience of boulders leads me to believe that we should look rather to the S. & W. of that district than to the N. & E. for their source.

External Features.—The general form of the block may be described as an irregular parallelopiped having the dimensions already given. The end upon which the stone now rests (the N.W. end as it lay originally) is rough and blunt, while the opposite end is somewhat tapered. The sides are somewhat evenly curved and retain a crust of much weathered rock with a strong ferruginous stain such as might be expected to result from the exposure of a rock of the like chemical composition for a long period to the atmosphere. The occurrence of this weathered crust is a fact of great significance.

The upper surface (that which faces outward towards the quadrangle) is somewhat smoothed though not quite flat, and is *longitudinally* striated. Small eminences occur upon the surface, and by a careful examination of these it may be seen that they are "moutonnée," and that the lee-side of each little hummock retains vestiges of a ferruginous decomposed crust similar to that seen upon the sides of the boulder. The lee-side is invariably the S.E. (upper) side, consequently the friction must have been from the opposite side. Upon the lower side of the stone the striæ are very strong and deep,

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and their direction (determined by the moutonnée hummocks) is from the eastern corner. From the consideration of the foregoing facts it will be seen that a very small amount of glaciation had taken place, and that the rock has not been materially and indeed hardly perceptibly altered in general form by glacial agencies. One singular feature is presented by the boulder, which, I believe, has not been hitherto recorded of any British erratic, viz. :—It exhibits distinct traces of fracture either by great pressure, or, as it seems to me, more probably, by concussion previous to its glaciation. On the south-western edge of the upper surface a scar can be distinctly seen whence a flake has been broken, and from the fact that the edges of the scar are smoothed and rounded, it is evident that it was produced before the smoothing and scratching of the boulder. A similar scar is visible upon the north-eastern side at the north-western end (lower). The fractures, in my opinion, were produced by a blow, as they do not bear the relation to the striæ, which might be expected supposing them to have been the result of pressure as, or by, a slow moving mass in a glacier. In the latter case I should expect the striæ to run at right angles to the edge at which the pressure was applied, whereas their direction is parallel to it.

The explanation which I would offer is, that the boulder lay upon a hill-side exposed to the weather for ages, and thus acquired the ferruginous crust, that at some period in the glacial epoch, it was dislodged by an avalanche, and, thundering down from crag to crag, the fragments were struck off. Falling upon the surface of a glacier, such as the great ice stream which came down Ennerdale, it in course of time dropped down a crevasse, and gradually making its way to the bottom, was scrubbed over the rocky floor of the glacier bed, thereby acquiring the scratches which we see upon it. The various cross-currents which are known

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to exist in modern glaciers, may indicate the agency by which the stone was turned over, so as to be scratched on two faces, or it may be that the stone was dropped upon a moraine mound, and picked up again on a further advance of the glacier. However the scratches were inscribed, one thing appears to be tolerably certain, that is, that the boulder was not carried for any great distance in a position to be scratched, and, further, that its present *form* is practically that which it possessed while still lying upon its parent hill.

As to the mode of transport to its resting place in the Boulder Clay :—I incline to the opinion that it was carried by an ice-sheet the greater part of the way from the Cumbrian hills, and the remainder of the distance by a floating berg, from which it fell into *deep water*. This appears to be indicated by the distance to which the stone was driven into the Boulder Clay, and the underlying gravel. To the question—what evidence is there that the transport was mainly by an ice-sheet? I would reply that the almost complete absence of intermixture of Irish and Manx rocks, seems to me to be explicable only on the hypothesis, so ably advanced by the late Professor Carvill Lewis, that the Irish Sea was occupied by an ice sheet, the Cumbrian and Scotch elements of which alone reached the Manchester area. Before this question can receive any definite answer, a great deal of additional information is needed respecting the geographical distribution of boulders of the various exotic rocks.

Associated Boulders.

(a.) In the Boulder Clay.—Many local or possibly local rocks are present, such as Coal Measure Sandstone, Millstone Grit, Carboniferous Limestone and Chert, and fossiliferous Permian Limestone. Next in order of abundance may be reckoned rocks from the Lake District, such as Andesite, Rhyolite, Volcanic Agglomerate, Qz. Porphyry, the so

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called Syenite of Buttermere (really a Granophyre), the Granite of Muncaster Fell, and various sandstones and grits. Of these the most abundant is unquestionably the group of Andesites. The Granites of Kirkcudbrightshire close the series.

(*b.*) *In the Gravel.*—Nearly all the foregoing rocks make their appearance, but in very different proportions from those found to obtain in the Boulder Clay. Coal Measure Sandstones are relatively far more abundant, and probably constitute three-fourths of the whole. After these come the Granites, both Scottish and Cumbrian, and in an insignificant minority are the Andesites and their kindred. The stones are of small size, and very rarely show signs of glaciation—indeed, taken as a whole, the deposit looks more like a coarse river-gravel than a glacial accumulation. These facts undoubtedly possess a high significance, but what that may be I do not at present venture to suggest.

In conclusion, I would remark that many details are here given which may appear trivial and unimportant, but there will come a time when every item of information regarding our glacial deposits will be seized upon and utilized in the solution of the great problem of how our island was affected and what was its physical condition during the great Ice Age.

Andesite Boulder.		Coniston Rock.	
Si, O_2	63·60	Si, O_2	65·80
$Al_2 O_3$	20·81	$Al_2 O_3$	20·66
$Fe_2 O_3$	3·02	$Fe_2 O_3$	5·03
$Ca O$	3·36	$Ca O$	3·76
$Mg O$	trace	$K_2 O$	1·68
$Na_2 O, K_2 O$.....	9·21	$Na_2 O$	2·20
	100·00		99·18

Traces of Mn. present in both specimens.

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A vote of thanks having been passed to Mr. Kendall,

The CHAIRMAN said he had seen the boulder in question, and it certainly was a remarkable one: it was the largest, or one of the largest, he had even seen. He must, however, take exception to the inscription which had been put upon it, to the effect that it had been carried there by ice. It was doubtless conveyed there by some means, but how, there is no evidence to show. The glacial theory is merely hypothetical. Our globe is but one of a series of planets, and the transporting of boulders may easily be imagined amongst the changes which would occur as each planet took its orbit.

In answer to a member,

Mr. KENDALL said he had, in the paper, expressed the opinion, and stated what he considered to be valid grounds on which to base that opinion, that in this particular instance the boulder had been transported by an ice sheet; but he must disclaim all responsibility for the inscription on that boulder.

Mr. DE RANCE said he would like to bear his testimony to the care and accuracy which the author had evidently bestowed upon his paper. No one knew more than members of the Geological Survey, how valuable it was to have local observers who took advantage of railway cuttings, the making of sewers, and what not, for noting the peculiarities of local strata. It was only by careful and detailed examination that they could hope to arrive at a knowledge of the geological details of the country; and it appeared to him, Mr. Kendall's was a paper of that class—a paper which was particularly suitable to bring before a local Society. With regard to the inscription on the Oxford Street boulder, he, for one, with all deference to the Chairman, should say that it was a right one to put upon it.

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Whether it came by floating ice, or whether—as he gathered from his paper Mr. Kendall seemed to think—by land-ice, was a matter of detail; but, as far as he knew, there were only two sorts of ways in which it could otherwise come—one, that it was a boulder thrown out of the cone of a volcano, (and it was obvious it could not be that), and the second was, that it might have been brought down by floods, as boulders of a certain size sometimes were, entangled in the roots of trees. It seemed to him, however, that this particular boulder was too large to be conveyed in either of those ways, and the only possible method of transportation had been by ice.

THE LATE EARTHQUAKE SHOCK.

Mr. De Rance made a brief reference to the earthquake shock which was felt throughout a great part of Lancashire on the night of Sunday, February 10th. He mentioned the singular fact in connection with the earthquake which visited Essex two or three years ago, that in some deep wells the water level was raised, and it continued at the higher level for some months. At Colchester the Water Committee appointed a certain day to consider the question of lowering the pumps, but in the meantime the earthquake came, raised the level of the water and so rendered the contemplated step unnecessary. His object in mentioning the matter was to ascertain, if possible, whether any similar phenomenon had been observed to follow the earthquake in this district.

A brief conversation took place, but no phenomenon such as Mr. De Rance had mentioned was stated to have been observed.

The Chairman said he was at home reading at the hour the shock was stated to have occurred, but he did not feel it.

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One of the servants, however, in an upper room said, she was nearly thrown out of bed.

Mr. De Rance said that ten years ago there was an earthquake shock at Preston, rather shorter than the one recently felt, and in that case it was noticed that it was more sensibly felt by people up stairs than by those on the ground floor.

Mr. Stirrup said there was evidence of the recent shock having been felt over a pretty wide area, embracing the district south of Manchester.

After some further conversation the subject dropped and the meeting adjourned.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, March 12th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, JOHN KNOWLES, Esq., M.Inst.C.E., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. WILLIAM BELLHOUSE SCOTT, Engineer, 133, Manchester Old Road, Middleton.

Mr. ARTHUR BIRTWISTLE, Colliery Proprietor, Great Harwood Collieries, near Blackburn.

Mr. WILLIAM TAYLOR, Colliery Manager, Whitebirk, Blackburn.

Mr. JOHN TAYLOR, Colliery Manager, Great Harwood Collieries, near Blackburn.

Mr. EDGAR O. BOLTON, Mining Engineer, Burnley Collieries, Burnley.

Mr. LEES KNOWLES, M.A., LL.M., M.P., of Pendlebury and London, was elected a Life Member in accordance with Rule VIII.

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The following are the recent additions to the Library :—

Belfast Natural History and Philosophical Society: Report and Proceedings, 1887-8.—*From the Society.*

Bradford Free Libraries: Eighteenth Annual Report.

Bristol Naturalists' Society: Proceedings, Part 3, Vol. V., 1888.—*From the Society.*

Chesterfield and Midland Counties Institute of Engineers: Transactions, Vol. XV., Part 8, Vol. XVII., Parts 1-2.—*From the Institute.*

Cornwall, Mining Association and Institute of Cornwall: Transactions, Part 1, Vol. II.; Report of Eighth Exhibition.—*From the Institute.*

Cornwall, Royal Institution of: Journal, Part 3, Vol. IX.—*From the Institution.*

Cornwall, Royal Geological Society of: Transactions, Part 3, Vol. XI.—*From the Society.*

Devon and Exeter Albert Memorial Museum: Report, 1888.

Dublin, Royal Dublin Society: Scientific Proceedings, Parts 7-8, Vol. V., Parts 1-2, Vol. VI.; Scientific Transactions, Vol. III., Series 2, No. 14, Vol. IV., Series 2, No. 1.—*From the Society.*

——— Royal Geological Society of Ireland: Journal, Part 2, Vol. XVII., 1885-7.—*From the Society.*

Edinburgh Geological Society: Transactions, Part 4, Vol. V.—*From the Society.*

Essex Naturalist: Nos. 7-10, Vol. II.—*From the Essex Field Club.*

Glasgow, Natural History Society of: Proceedings and Transactions, Part 1, Vol. II., New Series, 1886-7.—*From the Society.*

Geological Society of Glasgow: Transactions, Part 2, Vol. VIII.—*From the Society.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 1-3, Vol. V., Part 9, Vol. IV.—*From the Society.*

Halifax, Geological and Polytechnic Society of Yorkshire: Proceedings, New Series, Part 1, Vol. XI.—*From the Society.*

Leicester Literary and Philosophical Society: Transactions, Parts 8-10.—*From the Society.*

Liverpool Science Students' Association: Proceedings and Report, 1887-8.—*From the Association.*

——— Geological Society: Proceedings, Part 4, Vol. V.—*From the Society.*

London, Royal Society: Proceedings, Nos. 268-272, Vol. XLIV., Nos. 273-275, Vol. XLV.—*From the Society.*

——— Geological Society: Quarterly Journal, Nos. 175-177.—*From the Society.*

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London, Geologists' Association: Proceedings, Nos. 7-8, Vol. X.—*From the Association.*

——— Geological Magazine: Nos. 290-297.—*Purchased.*

——— Royal Institution of Great Britain: Proceedings, Part 2, Vol. XII.—*From the Institution.*

——— Institute of Mechanical Engineers: Proceedings, Nos. 2-4, 1888.—*From the Institute.*

——— Iron and Steel Institute: Journal, Nos. 1-2, 1888.—*From the Institute.*

Manchester Association of Engineers: Transactions, 1888.—*From the Association.*

——— Owen's College Calendar, 1888-9.—*From the Council of the College.*

——— Literary and Philosophical Society: Memoirs, Vol. I., Fourth Series.—*From the Society.*

Midland Institute of Mining Engineers: Transactions, Parts 96-100, Vol. XI.—*From the Institute.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Parts 5-6, Vol. XXXVII.—*From the Institute.*

North Staffordshire Naturalists' Field Club: Report and Transactions, 1888.—*From the Club.*

Salford, Annual Report of Museum, Libraries, and Parks, 1887-8.

Scotland, Mining Institute of Scotland: Transactions, Parts 3-8, Vol. X.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, Nos. 1-2, Vol. XVI.—*From the Institute.*

Etheridge's British Fossils-Palæozoic: Vol. I.—*Purchased.*

Prestwich's Geology, Chemical, Physical, and Stratigraphical: Two Vols.—*Purchased.*

Deep Borings in Trias, Teignmouth. Pamphlet by G. W. Ormerod.—*Presented by Author.*

Mixed Accidents in Mines. By A. R. Sawyer.—*Presented by the Author.*

Mining Manual for 1888.—*Presented by W. R. Skinner.*

Journal of British Society of Mining Students, May, 1888.—*Presented by W. S. Gresley.*

Presented by Mr. William Whitaker, F.G.S.:—

Geological Sketches of the Precious Metal Deposits of Western U.S.A., 1885.

Bulletin U.S. Geological Survey of Territories: No. 1, Vol. V., 1879.

Mines and Minerals of British Columbia. G. M. Dawson, 1877.

Work of International Congress of Geologists. Pamphlet by G. K. Gilbert, 1887.

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Pamphlet, Chotts Tunisiens, Hydrologie, &c., 1881.

Pamphlet, Der alte Bergsturz im H. A. Heim, 1883.

Pamphlets, Geological Survey of Great Britain, Explanations of Horizontal Sections: Sheets 18, 41, 42, 54, and 61.

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Pamphlet, American Geological Classification and Nomenclature. By Jules Marcou, 1888.

Pamphlet, Führer Kgl. Mineralogische, Geol. Museum zu Dresden, 1887.

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Canada, Geological and Natural History Survey of Canada: Maps to Vol. II., 1885.—*From Director of Survey.*

——— Canadian Institute: Proceedings, Fasc. 1, Vol. VI., Third Series.—*From the Institute.*

——— Ottawa, Canadian Mining Review: Nos. 7-12, Vols. VI. and VII., No. 1, Vol. VIII.—*From the Editor.*

——— Halifax, N.S. Nova Scotian Institute of Natural Science: Proceedings and Transactions, Part 2, Vol. VII., 1887-8.—*From the Institute.*

U.S.A., Harvard College: Bulletin of the Museum of Comparative Zoology, No. 10, Vol. XIII., Nos. 2-3, Vol. XVI., Nos. 1-2, Vol. XVII.; Annual Report of Curator of Museum, 1887-8; Harvard University Bulletin, No. 42, January, 1889.—*From Alexander Agassiz.*

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——— New York, American Institute of Mining Engineers: Transactions, Vol. XVI.—*From the Institute.*

——— Philadelphia, Academy of Natural Sciences: Proceedings, Part 1-2, 1888.—*From the Academy.*

——— Philadelphia, Journal of Franklin Institute: No. 1, Vol. XCI., Nos. 753-756, Vol. CXXVI., Nos. 757-8, Vol. CXXVII.—*From the Institute.*

——— Washington, Smithsonian Institution: Annual Report, 1885, Part 2.—*From the Board of Regents.*

——— Washington, United States Geological Survey: Monograph, Vol. XII. and Atlas; Geology of Leadville, Colorado.—*From Director of Survey.*

——— Pennsylvania, Geological Survey: Annual Report and Atlas, 1886, Part 4. Atlas of Northern Anthracite Coal-field, Part 2. Atlas of Eastern Middle Coal-field, Part 2.—*From Director of Survey.*

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——— Elisha Mitchell Scientific Society: Journal, Part 2, 1887, Parts 1-2, Fifth Year.—*From the Society.*

——— Pottsville, Pa.: The Colliery Engineer, No. 12, Vol. VIII., Nos. 1-7, Vol. IX.—*From the Editor.*

Eozoon Canadense: its Geological and other Relations. By Sir J. W. Dawson. Eozoic and Palæozoic Rocks of Atlantic Coast of Canada. By Sir J. W. Dawson. Notes on Balanus Hameri. By Sir J. W. Dawson. Notes on Cretaceous Plants, from Port Mc.Neill. Pamphlets. By Sir J. W. Dawson.—*From the Author.*

India, Calcutta, Records of the Geological Survey of India: Parts 2-4, Vol. XXI.—*From the Government.*

Berlin, Zeitschrift der Deutschen Geologische Gesellschaft: Heft 1, and April-June, 1888, Band 40.—*From the Society.*

Brussels, Catalogue Illustré des Coquilles Fossiles d'Eocéne de Paris.—*Purchased.*

——— Société Royale Malacologique de Belgique: Annales, Vol. XXII., 1887, Procés-Verbaux, Vol. XVII., 1888.—*From the Society.*

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Christiania. The probable cause of the displacement of Beach Lines: Pamphlet by Professor A. Blyth. Additional Note by Professor A. Blyth.

——— Variations of Climate in Course of Time: Pamphlet by Professor A. Blyth.—*From the Author.*

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——— Die Versteinerungen des Cambrischen Schichten systems der Insel Sardinia: Nos. 1-33.—*From the Academy.*

Kieff, Russia, Mémoires de la Société des Naturalistes: Vol. IX., Books 1-2.—*From the Society.*

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——— The Gold Fields of Victoria: Report of Mining Registrars, 30th June, 1888, Report, September, 1888.—*From the Government.*

——— Mines and Water Supply, Victoria: Report, 1887.—*From the Government.*

——— Mineral Statistics of Victoria, 1887.—*From the Government.*

——— Prodromus of Zoology of Victoria, 1888. By F. Mc.Coy.—*From the Author.*

Sydney, Royal Society of New South Wales: Journal and Proceedings, Part 1, Vol. XXII., 1888.—*From the Society.*

——— Geological Survey of New South Wales: Memoir, No. 1, Palæontology, 1888.—*From the Government.*

——— Department of Mines: Annual Report, 1887.—*From the Government.*

New Zealand, Reports on the Mining Industries of 1888.—*From the Government.*

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THE EARTHQUAKE SHOCK OF FEB. 10TH, 1889.

The PRESIDENT referring to this occurrence said:

I have had enquiries made at various collieries in the district to ascertain the observations made by the workmen who were employed at the time of the earthquake.

The following are the results:—

PENDLEBURY COLLIERY.

At about 10-30 p.m. the colliers on No. 9 East side, Rams Mine came out of their working places to the engine brow and reported to the fireman that they had heard a very heavy rumbling noise in the roof of the working places. The Fireman went back with them and examined all the East side again but could find nothing fresh since his previous examination at 5-30 p.m.

AGECROFT COLLIERY.

Only one man noticed anything. He was in No. 2 Pit and when he heard the sound he went out on to the pony road to see if it had been caused by a fall of dirt.

CLIFTON HALL COLLIERY.

None of the men, either on the surface or underground, heard or saw anything unusual. No shock was felt underground. No burst of gas took place in any part of the workings.

PENDLEBURY COLLIERY.

Nothing was noticed.

CLIFTON MOSS COLLIERY.

No one was in the mine and the men on the surface did not notice anything unusual. On Monday morning, when the mine was examined, there was more broken timber, more legs pushed out, and more falls of dirt than usual.

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From these reports there does not appear to have been any material disturbance in the coal measures, although the places where the men worked are at various depths, and there was no indication of the cause of the earthquake such as might have been observed by the men.

A circumstance occurred at the time of the Clifton Hall explosion, which took place on June 18th, 1885, which to a certain extent may lead one to think of a cause which may create earthquakes.

The explosion was a very serious one, and I understand at the time that a tremor of the earth took place in Broughton, about two miles to the east; and some persons considered this was an earthquake.

I have thought over this subject since then, and although I do not put this forward as a certainty, I think it is worthy of consideration by the members of the Society and those who may take an interest in such a subject.

We all know that there are various electric conditions in the atmosphere, and at times one part is over charged with electricity and another part in the negative. Under these circumstances, whenever they come into contact, there is sure to be a mutual distribution of electricity until they are equal, causing at the time of contact a violent *explosion*, creating thunder and vibration.

There are also times when there is also a difference in the electrical conditions of the atmosphere and the earth, and immense quantities of electricity are transmitted from the clouds to the earth.

I have twice seen trees struck with lightning, and also a cottage chimney struck by it—showing an immense amount of power.

Under these circumstances which apply to the atmosphere, may it not be possible that earthquakes may be caused by

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the various electric conditions of the crust of the earth—and this may be intensified by any surplus addition from the atmosphere. I think it has often been noticed that before an earthquake the atmosphere seems charged with electricity. This was certainly observed on the Sunday afternoon of the 10th February, and it has been noticed in other places previously. In thinking this over, I can quite imagine that there might be a great difference in the electric conditions of the various parts of the crust of the globe—which it would be impossible to observe; but if there is an interchange of conditions this could only be done by a serious disturbance underground, and thereby causing the earth to tremble.

In cases where earthquakes take place near to volcanoes, these may materially add to the more violent results—and may no doubt be caused by the extreme difference of electric conditions of the earth.

Mr. Dickinson said he recollected when the explosion took place at Clifton Hall, an earthquake was reported in the newspapers to have occurred about the time in Scotland, and that was referred to by himself in the course of the investigation; but so far as was then known there was no evidence of such a shock having been felt so near as Broughton. One would like to know on what evidence the shock at Broughton is now ascertained to have taken place.

The President said it was certainly remarked at the time: he had no other evidence.

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THE EFFECTS OF ROBURITE FUMES.

By Mr. Henry Bramall.

Mr. Bramall said: I have a matter to bring before the Society which may be of interest to those members who are connected with mining, or at least to those who are interested in the use of Roburite in mines. We recently had a paper (at the reading of which I was not able to be present), detailing certain experiments in the using of Roburite. It was claimed for Roburite that it was the best explosive yet invented, that its use was unattended by any risk from ignition of fire-damp, and the manufacturers state that no noxious fumes are given off. We have been using this explosive at some of our Pendlebury Collieries for about four months, and for certain reasons, I have been led to give particular attention to the effect of the fumes upon the health of the workmen. I sent for the men who had been using Roburite longest and examined them, and they appeared to me to be very seriously out of health. They seemed to have been poisoned. I then asked my friend Dr. Berry, who has kindly consented to attend here to-day, to take these cases in hand, to investigate them as thoroughly and strictly as possible. This he has done, and he will, with your permission, state the result of his observations. It would appear that the theoretical equation given by the makers of Roburite of the change which results from its explosion, is not always to be relied upon in practice. The substance is stated to consist of 1 part of di-nitrobenzene in which an atom of hydrogen has been replaced by an atom of chlorine, and 9 parts of ammonium nitrate, and the products of the explosion ought to be free nitrogen, water, carbonic acid, and a little hydrochloric acid.

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But I believe from what we see of the cases we have recently investigated, that there is also some carbonic oxide generated, and this, we all know, is the most deadly gas with which we ever have to contend in coal mining. I believe it is to this that the illness apparent amongst the miners is chiefly due. Their symptoms are consistent with carbonic oxide poisoning, and have, in my opinion, been occasioned by inhaling the fumes. The Roburite Company state that there is no danger in the use of this explosive except such as may arise from handling the material, but I am strongly of opinion that there certainly is danger in breathing the fumes, and that the men who use it, ought to be warned against that danger. They should not go into these fumes, nor return to work in their places until the fumes have been cleared away.

There is another point which has suggested itself to me, and that is, whether a portion of the di-nitrobenzene might become vapourised, when, for instance, the explosion, as sometimes happens, is not perfect. The inhalation of this vapour might give rise to very serious disturbance of the men's health because it would combine with a certain constituent of the blood to form aniline with resultant poisonous effects which are well known.

I have asked Dr. Berry to attend this meeting in order that he might, if you should wish it, describe to you the symptoms he observed in those men. That, of course, he can do much better than I can.

Dr. J. J. Berry (of Pendlebury) said: My attention was called by Mr. Bramall to certain men who had been using Roburite, and I was requested to examine them, and they have since been under my treatment. There were six cases, and the symptoms were more or less similar in each of them. I will not trouble the Society with the details of

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each case, which would be of more interest to medical men, but will give briefly, from my notes, the more important symptoms of what might be considered as a typical case.

G. G. was a strongly built man of 48 years of age, who had previously enjoyed good health. He had been using Roburite for about four months. His first symptoms were smarting of the eyes and face, and pains beneath the shoulder blades, and in the temples and back of the head. These were followed by numbness in the tips of the fingers and in the toes, shortness of breath, constriction of the chest, and palpitation on slight exertion. These symptoms became more pronounced, and after having used Roburite about three months dimness of sight came on, with aversion to light, motes and stars dancing before the eyes, twitching of the muscles of the eyeballs, and a marked diminution of the physical strength. The patient suffered from pains in the limbs, griping pains in the abdomen, nausea, and occasional vomiting. This was succeeded by drowsiness and unnaturally prolonged sleep. The patient has lost about a stone in weight. He is very anæmic, and suffers from great nervous prostration.

There were other symptoms of interest chiefly to medical men. I may, however, mention that I have examined the blood of the men affected with the spectroscope, and have found in it traces of carbonic oxide.

I consulted Dr. Ross as to two of the most typical cases, and on examination he pronounced them to be cases of carbonic oxide poisoning; an opinion in which Dr. Dreschfeld also concurred.

In my opinion the primary cause of the mischief has been inhalation of the fumes, and not the handling of the substance.

With respect to the suggestion thrown out by Mr. Bramall as to the effect of breathing di-nitrobenzene in a vaporised

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state, if such a thing occurred, the result would be that aniline would be first formed in the blood, and would be oxidised, and afterwards reduced to form mauve and magenta, which are deadly poisons.

Mr. STIRRUP asked if the symptoms described had been observed only since the introduction of roburite?

Dr. BERRY: Only since the introduction of roburite. We never met with such symptoms before. All these half dozen men I have had under treatment were healthy and strong men to begin with. Some of them I have known personally for years, and in the case of one or two that I have not known I have made a thorough examination as to their physical condition; and if they had been suffering from any organic disease it would have brought about changes in the system which I should have marked.

Mr. STIRRUP said he had much pleasure in moving that the thanks of the meeting be given to Mr. Bramall for introducing this subject, and also to Dr. Berry for his remarks on the same. It was a most important matter to gentlemen connected with the colliery interest.

Mr. DICKINSON seconded the motion, and said he wished that Mr. Hall had heard the remarks of Mr. Bramall and Dr. Berry, as he could have given them his experience of a colliery in the Wigan district where roburite had been extensively used. The whole subject was of importance, and it showed that there was no improvement which was not accompanied by some drawback. This statement by the manufacturers that there was nothing noxious in the fumes of roburite was, he thought, to be deprecated.

Mr. BRAMALL said: I would like to say Mr. President, that, I have not brought this matter forward from any desire to condemn the use of roburite in mines. In fact, it

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was only yesterday that I gave an order for a further supply of it; but what I want to emphasise is this—that the statement of the manufacturers that no noxious fumes are given off is misleading, and should be received with caution. Roburite should only be used where there is good ventilation, and men should not be allowed to breathe the fumes. The men ought not to be permitted to return to work until the fumes have been cleared away. If this rule is strictly observed, I think roburite is a boon to those who find it necessary to use explosives in the working of collieries. I have another reason for mentioning this matter. It will be in the recollection of many of those present that when gun cotton was brought out some years ago, great stress was laid upon the statement that no noxious fumes were given off. Some experiments were carried out at the Halkyn Deep Level, I think in 1878, and after firing some shots a number of people rushed into the level immediately before the fumes had cleared away, and the result was that one man lost his life, and eleven others suffered severely from carbonic oxide poisoning. I trust the attention now called to the matter may prevent any similar occurrence arising from similar statements now put forth with respect to roburite.

Mr. Herbert Fletcher: Can Mr. Bramall tell us whether roburite possesses advantages from the fact of its being flameless, does more work, or is cheaper than gunpowder?

Mr. Bramall: Well, I hardly care to enter into a discussion as to the advantages of roburite, that is not my object in bringing the matter forward to-day.

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SOME FURTHER REMARKS ON THE OXFORD STREET SECTION.

By Mr. Charles Roeder.

Mr. Theodore Sington laid before your Society on the 5th June, 1888 (Part XX., Vol XIX., page 603), a section dealing with the excavations in Oxford Street, Manchester, for the construction of a sewer, and it is my intention, with your kind permission, to bring the subject again forward, not for the purpose of generalising or expanding any views with regard to the bearing or the evidence this fine section may afford, but merely to illustrate matters a little further by means of a series of specimens consisting mainly of various clays, loams, gravels and sands, as obtained from the shafts at different points, both in natural state or washed, separated and repeatedly sifted, so that you may be enabled to obtain a clearer idea of the nature and composition of the material which forms our local deposits. Would time allow and were I not afraid to detain you too long, I would have liked to go a little more fully into the subject and give you an account of the microscopical appearance of the sands, as regards shape, size and structure, and also the percentage and proportion that exists between the sand and clay of this boulder-clay, and further the specific gravities of its composition, and any conclusions to be derived from the study of these various points; but I hope to put you in possession of such details at some later date, if agreeable, and restrict myself to-day to making simply a few cursory remarks.

To show the extent of the local drift deposits I have brought Binney's old map, and also Mr. Sington's sections,

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which I coloured to make its features more prominent, and facilitate the examination of the specimens placed on the table. Of each formation I shall say a few words. And first of all with regard to the

Valley Gravels and Old River Terraces.—These deposits cover a large area of our townships, and are well developed on the southeast of Manchester, following the course of the bed of the Medlock and can be traced all over Hulme, resting in some places on till and sometimes direct on the trias. Our section shows the greatest thickness of these deposits to be reached about Boundary Street, where they measure 11 feet. Sometimes we also find below the gravels beds, blue silt, for instance, according to Binney, in River Street, where imbedded in it was discovered a large oak tree and branches, and portions of pine and hazel. Similar inclosures I found two years ago in Grecian Street, near Albert Park, Lower Broughton, along with fine trunks of beech and beech leaves, oak, and innumerable quantities of hazel-nut, perfectly green when taken out, but immediately shrinking and turning black on being exposed to the atmosphere. The question at once presents itself: Is there any clue to the age of these ancient gravels? Mr. Hull, when surveying our locality in 1864, took great pains to discover any implements in the older river-terraces, without, however, being successful. But since then various finds have been made in the immediate neighbourhood. I speak of the brownish quartzite stone-hammer, 3in. by 5in., found 1870, about 20 feet below the surface in Corporation Street, now in the possession of the Rev. Mr. Burns, of Clayton Hall. In 1887 I likewise obtained at the bottom of the river gravels between Sidney Street and Grosvenor Street, an implement, of hatchet shape, made of black ironstone, and also in Grecian Street, Lower Broughton, from the gravels, near which locality I also discovered a fragment of Roman fresco

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and parts of a black-ware pottery, a large scraper of black chert. To this I may add the wooden box, formed of four upright posts, driven into a bed of clay, 12 feet below unbroken gravel in Castlefield, near the tunnel mouth. The sides and bottom were closed in with logs of wood, and these rudely hewn and riven, not sawn, and 5 to 6 inches square, mentioned by Elias Hall in his "Introduction to the Mineral and Geological Map of Lancashire," 1836. Bones, however, as far as my knowledge goes, have hitherto been looked for in vain in the older gravels of the Medlock, Mersey, and Irwell, as far as Manchester is concerned. It is not my desire at present to enter further into speculations in that direction, but these finds seem to make it quite probable that these old river borders were visited by the foot of man, both neo-and palaeolithic, and I hope that further careful search will reward us with additional corroboration to fortify us in this assumption. These terraces of the Medlock are now obscured to our view, being completely built over. As it may perhaps interest you to know of what form and extension these were, I have brought C. Laurent's old map of 1793, the only map, I believe, we have, to show the formation of the ground round the town. The terraces are sharply shaded, following the course of the river. The specimens, to illustrate the gravels, were taken by me from the old Roman Castrum, Collier Street, off Bridgewater Street, Deansgate, and consist of Roman mortar, the composition of which already has been analyzed by Dalton. There is no mistaking the material obtained from this separated mortar. From the scattered remnants of vegetation found in the silts and gravels, we may almost form a picture of the aspect of the vicinity, covered as it must have been with the growth of oak, beech, hazel, &c., on the more elevated ground, while the lower levels, stretching away in the direction of

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Chorlton, Stretford, Withington, and Cheshire, would give rise to the formation of extensive moors and mosses, richly clothed with gorse and heather, etcetera.

Red Marls.—The next feature in Mr. Sington's section is the occurrence of red and green marls, extending from Grosvenor Street to Rosamond Street. Binney, in 1841, traced these bands in Chepstow Street (4-5 feet thick). Again at All Saints (12 feet). He notes their resemblance to Fuller's earth; on treating with hydro-chloric acid a brisk effervescence takes place, proving the presence of carbonate of lime. Unfortunately Mr. Sington could not obtain the dip of these beds. Binney says 8° to the W.S.W. I have been unable to discover shells in it; they are so much like the Permian marls that the temptation lies near to consider them as belonging to that group. In Chorlton-on-Medlock, 1864, at the works of Fryer & Co., red marls with limestones were reached at the depth of 114 feet, 237 feet thick, while in the Oxford Street section they have been found at 26 feet. It will be observed that here there is a very abrupt, almost perpendicular rise of the triassic pebble beds; it may be that these red marls have been thrown up, and that we have to look to some fault to account for this state of things, although the geological map of the district does not give us any such indication. Binney classed them first with the upper red marls, but afterwards relegated them to the lower new red sandstone pebble beds. These are followed by and pass into an arenaceous sandstone, which is characterised by the exhibition of calcite growths, which are scattered through the matrix in the shape of nuggets, as large, very often, as big peas. I have brought you specimens. Meanwhile, in the absence of further stratigraphical help, it is difficult to form a correct notion of the proper relation of these beds, whether we must consider them Permian or Triassic.

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4. The Trias.—Here the pebble beds have been traced to the Lamp Eye Shaft. The thickness is unknown. They thin out at Medlock Vale Print Works, where they have been proved 23 feet thick; in Chorlton-on-Medlock they are stated to be 114 feet thick, and at Wörrall's, in Ordsall Lane, 460 feet. These beds consist of coarse-grained red sandstone, rather soft, with numerous pebbles of quartzite, hornstone, and occasionally granite, and the surface not unfrequently decidedly polished, and here and there are found intercalated bands of marl and blackish iron incrustations. I have washed the mass and you can examine both grain and colour of its component elements. It appears almost that the trias, in the present case at least, must have been a factor of little weight in the determination and composition of the boulder clay. We find in the pebble beds in Oxford Street, as elsewhere, a large number of big round and oval quartzite pebbles, but with all the attention I have given to the boulder clay along this line, I scarcely remember a few cases where I have come across the presence of any of these pebbles in it.

5. The Boulder Clay.—The greatest thickness is reached at Thorncliffe Street, 32 feet thick, and dies away again slowly in the direction, as far as the shafts are concerned, of Fallowfield, when we see the trias cropping up within 5 to 6 feet from the surface. The prevailing colour is here generally greyish brown, and when not laminated and foliated has a compact angular appearance, in consequence of the large inter-mixture of stones. Its composition in the neighbourhood varies a great deal, and a study of washings and siftings brings out many interesting facts. I must, however, abstain from touching this matter; what strikes us mostly, on the first look, is the overwhelming percentage of shale, coal, grit, and sandstone pebbles, which almost seem to make up the whole of the stony part of the

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boulder clay, which will become quite patent to you from the comparison and examination of the washings before you. The destruction and denudation of the exposed coal measures must have been enormous at the time our district, and Lancashire in general, was exposed and subject to the abrasion caused by the long lingering invasion of glaciation and other agents; the larger grains of sand obtained from the boulder-clay wash are, on the whole, mostly rounded, and the smaller ones of a more subangular nature, which would seem to point out the source from whence they were derived, viz., the coal measures and the trias. You also find amongst them many rounded black shale grains of the size of a pin's head. Hull and many other geologists in these parts have expressed themselves to the effect that these clays were quite deficient of marine shells. But not only have I traced shells in all the clays, both coarse and foliated and bookleaved, of our neighbourhood (viz., Cheetham, Broughton, Strangeways, Crumpsall, Stretford, Openshaw, Clayton, Oxford Street, Rusholme, Fallowfield, &c.), but also in the gravels and sands. If you carefully wash these tills in fine muslin bags you are sure to find in the residue, as a rule, shell fragments. Another point which deserves notice is the occurrence of Permian boulders in the till. I think we can have no better guide for tracing the particular movements of our local drifts, because the Permian area is pretty well guaged. I have obtained them from George Street, Owens College, right down to Fallowfield; again at Dixon's Fold, Stoneclough, Crumpsall, Clayton Bridge, Alkington, Failsworth, Heaton Mersey, Stockport, &c.; to the west, that is on the Cheshire side, they seem to break off and disappear. There is another boulder I would like to mention, which is sometimes present, namely, Ardwick *Spirorbis* limestone. I have seen and collected it in the clays east of Ardwick, at Clayton, Clayton Bridge,

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Openshaw, and south at Heaton Mersey and Stockport, but nowhere to the west of Manchester. I have looked for it on that side many years, and now and again along Oxford Street, but to no purpose. May it not indicate that there was a deflection of movements, brought about by the existing barrier of the insulated ovoid-shaped, at one side tapering Manchester coalfield, cut off at the east by a long fault and surrounded on all sides by the Triassic and Permian strata? From the foundation of Owens College, in 1884, I took a large piece of haematite; Mr. Plant found another in Lower Broughton, and it is quite possible to have drifted from the Patricroft outcrop, and creeping down in a south-easterly direction. The late Professor Carrol Lewis stated that flints in the till were only found south of Manchester; however, the excavations in Oxford Street have yielded quantities, so at Rusholme, Moss Side, Weaste, Openshaw, Ardwick, &c., for which and others I refer to my boulder-clay formation collection, presented to the Geological Museum at Owens College. Before I part from this subject, I must also mention the occurrence of pseudomorphs of the red marl series in the till of our neighbourhood, on the higher levels of Crumpsall, Cheetwood, Openshaw, Weaste, &c., and also at the lower grounds at Rusholme and Oxford Street. We find these red marls spread out on the west and north-west, and it therefore seems that these pseudomorphs must have been pushed forward hither from such direction. It may also account for the absence of the *Spirorbis* limestone boulders on the west side of Manchester. It is sufficient, for the present, to draw attention to these points, and with more data and material on hand we may hope to see more light thrown in the future upon the history of the glaciation of our district, which, practically, is scarcely touched and worked out yet.

I come now to speak of the large erratic block found

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near Ackers Street. Mr. Kendall and others have gone already so deeply into the description of this boulder that it is scarcely necessary to say any more about it. The side which faces south in the college yard represents the top of it when discovered *in sitû*, while the face which turns to the north is the original bottom. Both these sides are smoothed, lined and grooved. Top and bottom surface have the same longitudinal glacial lines, while in addition to this the latter has a set of transverse grooves, less distinct and rather worn and apparently much older than the longitudinal striae. It seems that the boulder must have been struck originally right against the central part, resulting in its breaking into two, and that which remains of it is but part of the mass. The lower truncated part looks as if very roughly handled, being extremely angular and irregularly fractured. While the upper part runs in a graceful curve, the other part presents the shape of a fracture line. The red band which runs across the lateral sides, passing over the apex, is not traceable on the fractured end, and would apparently confirm the views above expressed. Scattered over the upper surface are to be seen many holes, some almost circular, and not larger than the size of a nut, still filled with clay. The smoothed parts are of a whitish tint, while the bosses and humps incline to blueish grey. The lower surface shows two large fractures running across, as if knocked against. The anterior and posterior sides, as already said, are coated with a medial, deep red, shining, indented iron band, which again is fringed by a whitish mass, resembling an impressed paste. No doubt the whole boulder must have once been covered with this oxidised envelope, caused by the influence of weathering, and where we find it gone it has probably been abraded during and on its checkered voyage from its original home, borne either by ice-sheet or iceberg, till it was stranded and landed on the bottom of Oxford Street.

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Its long axis, which coincides with the direction of the longitudinal striæ, points to S. 37 E., and the boulder was found about 90 feet above sea level, and when lifted it became clear that its deposition could not have been effected by dropping from an iceberg, as the incurvated gravel on which it rested was neither smashed up nor broken. It is more probable that it was held fast and imbedded in a melting and rotten ice sheet, near its bottom, and gently carried and dropped. Otherwise we should find traces of the effect of the fall of a weight such as this boulder indicates. Binney describes the find in 1848 of another large block above Buckley's Sand Delph, Collyhurst, of millstone grit, about 5 tons weight, found under similar circumstances as the one in Oxford Street. The fine silt on which it rested has been pressed in like a basin, causing lamination, below which deposit there was a succession of homogeneous till.

Although the boulder is valuable as another contribution to the growing catalogue of erratics occurring in this vicinity, the fact of its having been found in Oxford Street, and secured by the College authorities, has given to it a pre-eminence and exaggeration quite out of proportion to its intrinsic importance and value. It does not add to our knowledge as regards the direction of the ice movement, no striæ have been obtained on the triassic floor of Oxford Street, and the long axis orientation is no indication deserving any special accentuation, it may be merely accidental, at any rate it is no safe guide. Those who have written and spoken about this block have generalised and treated it in too independent a manner, instead of co-ordinating it or showing the relation it bears in connection with the other numerous finds about Manchester. It is, indeed, not the *rarissima avis* for which a special case has to be made out, and further, it is quite a glaring mistake to assert

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that it has to be looked at as the largest block or the most memorable discovered in this district. Its weight, although estimated between 20 and 30 tons, is eclipsed by the fine grained gritstone (burr) boulder, found 1877 in Seymour Grove, Old Trafford, 90 feet above sea level, in till 20 feet thick, also scored with striæ, which could not be lifted, and had to be tunnelled though, its weight being 50 tons. Nor is the boulder of Oxford Street without comparison, for in a field near that street was found, in 1857, another boulder weighing almost 30 tons, of coarse greenstone, presented by Mr. James Hudson Beswick to the Park at Macclesfield. These interesting blocks are in reality of frequent occurrence hereabouts, and we easily can make up a list of 20 weighing from one ton upwards. Before we embark into any profitable excursions, it is imperative to map out the boulders of our district, marking the slightest points that elucidate and advance this question of glaciation. Mr. Strahan of the survey gives N.N.W. as the average direction of South Lancashire and Cheshire. Mr. Plant, reported 1868, the existence of distinct striæ at Ordsall Clough, namely, N. 40° W., and cites those of Park Hill, Liverpool, N. 42 W., Bidston N. 30 W., Kirkdale N. 15 W.

Another word, in conclusion, with regard to the gravels, loamy sands, and loams. All these—I speak of the Oxford Street section, have yielded shell fragments, and the gravels contain many rounded small Permian and Carboniferous limestone, and flint pebbles. Near Ducie Street and onwards we obtain a deposit of loam and loamy sands, which are of special interest for being almost wholly composed of *white millstone grit pebbles and brown ironstone. These may have been derived from and brought hither by land drainage from the easterly highlands. It seems that from about Brunswick Street a large river valley extended south-east towards

*See washed specimens.

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Fallowfield, where the trias rises again to the surface, and when we look at the large accumulation of loamy and gravelly material, appearing in that direction, we may, perhaps, ask ourselves whether there existed at one time a large water circulation, which could bring and sweep down such quantities of millstone grit matter, as we find in our district.

The thanks of the meeting were given to Mr. Roeder for his communication, on the motion of Professor Boyd Dawkins, seconded by Mr. Stirrup.

ON THE EFFECTS OF GOAF STOWING ON SUDDEN ISSUES OF GAS AND ON VENTILATION.

By Mr. Herbert Fletcher.

This paper is written in order to call the attention of our Society to the fact that explosions have never happened in well packed and what are called steep mines, whose inclination exceeds, say, one in six, and which are worked on the long-wall system without narrow work.

Reasons are given for supposing that mines thus worked are exceptionally safe.

This paper is also intended to excite discussion in the interests of our Society, and I hope the opinions given may be stoutly challenged.

We may divide sudden issues of gas into three classes, according to their source :—

1. "Blowers" issuing from natural fissures in ground undisturbed by workings—or "gas at home."

2. Influxes from accumulations in exhausted workings—or "gas in lodgings."

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3. Violent outbursts, as though from accumulations under pressure in cavities above or below the mine, formed by disturbance of neighbouring strata by the workings—or "gas in prison."

It is contended that all three classes of outbursts may be prevented. Let the opposition open the case.

Arguments "Against."

1. "You can't stow a spadeful of rubbish in the space from which you get a spadeful of coal." Granted. But you can stow two-thirds of one.

2. "Then you must have subsidence of the undermined strata." "Granted. But it will be to only one-third the extent."

3. "Then if the strata do not subside all at once, or as a single bed of stone, they must subside one after another; and spaces will thus be formed between them consecutively, which will be filled up again by the subsidences of the strata above." "Certainly, only that the less the first settlement, the less will be those which follow."

4. "These spaces cannot be ventilated; are therefore almost certain to be filled with gas; each consecutive subsidence is likely to put momentary pressure on this gas, and tend to force it downwards towards the working places of the mine; and the quantities of gas thus disturbed cannot be ascertained or exact provision made for them." "Granted again; but bearing in mind that the danger is one of degree only or scale."

5. "You are thus no safer with the goaf stowing than without it, so far as sudden issues of gas from the goaf are concerned." "Here we differ entirely." That does not follow.

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Arguments "For."

1. "The falling strata never entirely fill the spaces into which they fall. Cavities decrease in size as successive falls cause them to recede; there are all the corners that won't fit, and the above-mentioned spaces therefore tend to grow less as they recede towards the surface, and the original large cavity becomes transformed into a series of small ones among the broken rocks. These are not liable to further important changes; they tend to form vents to the surface, and are probably eventually closed by pressure."

This is commonly expressed by saying that the goaf "gutters up before it reaches the surface," and may explain why in deep mines gradual settlement of the surface takes the place of those surface breaks which accompany the working of shallow mines.

Gas recedes with each successive fall.

2. When a fall of the roof of one of these cavities takes place, the gas beneath it must rise into the space from which the stone falls, and be thus further removed from the mine. The stone cannot force the gas downwards without leaving a vacuum, or a partial one behind it, and the duration of this vacuum can but be momentary, until, that is, the gas has had time to rush back into that vacuum through the breaks of the subsiding strata.

Accumulation of gas at atmospheric pressure driven down by falls.

3. When an extensive fall of strong ground takes place a sudden movement or vibration of the air is produced, sufficient sometimes to throw open doors and to raise clouds of dust. When this has occurred a return movement of the air will be felt, called by colliers "a suck," just as after an explosion caused by the rush back of the air towards the

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vacuum created above the fall, or by the condensation of the watery vapour after the explosion. And then such gas as may have been driven down, will reascend to the fresh cavity above the fall.

The distance it first travels towards the workings, and the velocity of its impingement on the safety gauzes, if it reaches them, will depend on the extent of the fall, and on the facilities for the upward passage of the gas or air along the line of breakage to the fresh cavity formed above the fall.

It was to such forcing out of gas from an unpacked goaf that the explosions at Clifton and Hyde were attributed by the coroner's jury.

Pack walling—as distinguished from goaf filling—carried out to such an extent as is common, say 30 per cent. or a 3 yards wall in every 10, prevents the great and sudden falls alluded to above, and the sudden, though momentary, movements of air and gas which they may produce. For instance, a couple of pack walls in every 20, each wall being 3 yards thick, the intervals being alternately 3 and 11 yards, as is common, limit the width of the sudden falls, as distinguished from settlements, to the 11 yards. The cavity thus formed, however, becomes one of the natural harbours of gas to be mentioned later, and does not occur where the filling of the goaf is complete.

The stronger the roof,—the longer delayed will be such fall, also the greater may its extent be expected to be, and, consequently, the less its suddenness; because, if it does not break, that is, between the pairs of pack walls, it will have to crush them—a gradual process. It is the suddenness that constitutes the danger, and from this, as also from access to what cavity may be formed, the pack saves us in proportion to its solidity and power of resistance.

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Accumulations of gas under pressure.

4. The constant and usual yield of gas is provided for without difficulty by constant ventilation, and, if there are none of the foregoing accumulations at atmospheric pressure, gas is only to be feared as a cause of explosion when it rushes out—under the pressure due to its confinement in the strata—on being suddenly released from some natural fissure, or from some recently formed cavity in the roof or in the floor, due to the working of the mine.

These are the outbursts, against which it is commonly thought no effective precautions—beyond the abolition of naked lights and explosives—can be taken.

It is held that they constitute an ever impending danger, and to them most of the explosions have been attributed, both in this country and abroad.

"Blowers" from these natural fissures are met with in narrow work only—never in wide work—and they are always found to extend into the roof.

Certain mines in this country have become distinguished by these outbursts. They are all in proximity to thin unworked and gassy mines—either above them or below. They are all flat mines, and in no case have they been solidly packed.

The two instances of outburst given in the Report of the last Royal Commission on Accidents in Mines—at the Aldwarke Main Colliery, and at the Orgreave Colliery, Rotherham—are both cases of the bursting up of gas from the floor, along the face, on the sudden subsidence of strong ground above an unpacked goaf, the strong ground at Aldwarke being below the mine, where the gas appeared, and above the old workings of a lower mine, and occurring 10 hours after the "greatest weight" in the lower mine the manager had ever known; and at Orgreave the subsidence

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being that of a "first weight" of a strong roof, and where the "face" was advanced only 60 yards from the waggon road pillar.

Gas bags.

The possibility is generally admitted of gas pressure from below lifting tough and bendable strata of "floor," and remaining there in an inflated bag, as it were, until the accumulated hydro—or rather aero—static pressure becomes sufficient to burst the bag along the line of least resistance—that of the sharpest angle of bend—the line of the coal face.

The outburst of Aldwarke is an instance of this: the ground sinking from under the thin seams lying a short distance below the mine being worked.

It seems not improbable that a tough layer of coal or shale in the roof of a mine being worked may be acted upon in a similar way, but in a downwards direction.

The outburst at Orgreave seems to have belonged to this class, as, probably, do all "first weight" outbursts, unless indeed such as occur from a first settlement tapping some natural fissure, in which, and not in any bag, the gas has been imprisoned.

Outbursts: a. From the roof, accompanying first weights only. b. From the coal, occur only in narrow work. c. From the floor, the most common.

The more solid the packing, the less must be the probability of this bagging, both upwards and downwards; for, though a settlement of roof must, and a rise of floor may, take place, the formation of any considerable cavity—let alone a gas bag—is unlikely. Great pressure is required to compress the solid packing, and great pressure can only be exerted by a great thickness of strata, on the upper side of which the cavity world be formed, and through which the gas would have to force its way.

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It is difficult to imagine the formation of a gas bag in a roof after a general weight has taken place, but the floor is not broken up by falls as is the roof, and the effect of packing in preventing its rise, when relieved of pressure by the removal of the coal, and before the roof has settled upon it, seems obvious. We may expect the gas to come off through the gradually disturbed strata, and the packing secures constancy for that disturbance. Where there is no packing the weight on the face is always changing in its intensity, increasing after each break until again relieved by the next. The pressure is constant and of medium intensity when the goaf is stowed, and, as this produces a uniform condition of roof, danger from falls is lessened, and the work is less interrupted by them.

Effect on weight at the face.

Roof and floor treated as girders.

A solid pack is often said to prevent the relief of the face from the pressure of the overhanging roof, and thus to increase the crushing of the coal. As very few mines, however, are solidly packed, this opinion wants the backing of experience. Our experience at Ladyshore tends to establish the contrary opinion, and indeed, if the roof be considered as a girder or beam, it seems unlikely that supporting the free end of such a beam, when on the point of breaking, is likely to throw an increased strain on the points near the other end, which are supporting the beam. Here the free end is that part of the roof over the goaf, where the last break has taken place—the supported end lies on the solid coal—and the middle of the beam is the roof over the workings along the face of the coal.

This consideration of the strains on a beam is even more applicable to the forces tending to form a gas bag in the

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floor. The shorter the beam—that is, less the extent of floor relieved of weight—the greater must be the force required to lift or break it.

Effect of weight in preventing "Blowers."

5. A change of system from "pillar and stall" to "long wall" removes the danger from "blowers," as distinguished from outbursts, because on the approach of the wide "face" to the fissures in which the gas of such blowers is imprisoned, the coal is acted upon by the approaching weight of the roof overhanging the face, and a vent is given to these fissures by the breaks caused by the "squeeze."

These extend in advance of the face, and through them the discharge is gradual, and such as may be dealt with safely by a ventilating current of very moderate velocity—say the lowest, which can be measured by the ordinary anemometer—one not exceeding one foot a second along the face, provided, however, there are no holes in the roof inaccessible to that current.

Before such a current became dangerously charged with the gas ordinarily and silently issuing in imperceptible quantities from the coal, the appearance of a "cap" in the lamps, or the enlargement of the flame of the candles in the workings last traversed by the air, before it reaches the upcast, would give warning that the ventilation was insufficient, and the alternatives would present themselves of a suspension of work or an increase of the air in circulation.

Timely warning of danger is all a manager requires, and such fouling of the air from coal "pipers" cannot be sudden.

We have heard of outbursts in longwall workings in South Wales; but it should be borne in mind that the packing there is done under difficulties imposed by large trams holding twenty to thirty cwt., which cannot be taken across the face, the dirt from which has thus to be twice or thrice

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thrown by the spade—the mines are flat—rendering the stowing up to the roof difficult, as the roads are three yards wide and fifteen yards centres, and the outsides of the packs are supported by chocks of round timber, two yards apart. The area stowed effectively—supposing the stowing to be well done, which is very doubtful—is not more than 10 in 15 or 66 per cent. Moreover, these ten yard packs with five yard spaces—deducting, that is a yard from the sides of the packs for want of solidity—have probably far less resisting power than the same material would have in larger masses with larger spaces, although in the same proportion one to the other.

Effect on ventilation.

The materials for goaf stowing are chiefly taken from the air-ways of a mine—a fall in which comes to be regarded as cheaply got packing dirt, instead of, as in pillar and stall working, in mines too steep for tramming to the face, a difficulty to be suffered from, till a convenient opportunity occurs for its removal.

1. *Facilitates the removal of falls in the air-ways.*

This delay need not occur even in steep mines when the working places are all provided with the apparatus for transporting the fallen dirt to the face for stowage in the goaf.

The use of this apparatus, known as a spur-wheel jig, is essential to the Ladyshore system.

The effect of enlarging an air-way is to reduce the resistance to the passage of the ventilating current, not merely in direct proportion to that enlargement, but as the square of the proportion—a doubled velocity requiring a four-fold pressure to maintain it—and goaf stowing renders the enlargement a source of economy, as compared with the alternative of procuring the walling material from falls in

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the working places, intentionally produced by removal of the props. This, which is the common method in thick mines, may be described as making one hole to fill up another. Such holes, however, are in the roof, and not in the floor, and become the natural lodging places of gas, and this to a degree increasing with the flatness of the mines.

2. *Lessens extent of roads to be ventilated.*

It was not for its expected effect on ventilation, but to prevent the frequent falls that used to take place in the working places, that the goaf stowing was first tried at Ladyshore. It was sought to increase the faces in width and lessen them in number, in order to reduce the amount of narrow work requiring both maintenance and ventilation, and each road giving access to but one working place.

3. *Substitutes a good air course along the face for a bad one through the goaf.*

Under the pillar and stall system the air course through the goaf between the working places is generally impassable, and the men are then working on an average ten yards "out of the air," and depend on their lamps for safety from explosion, and this in an increasing degree as the mines become flatter through the absence of the natural ascensional drainage of the gas to one highest point. If this point is kept clear safety is ensured to all lower ones in the same panel.

4. *Prevents the formation of cavities in the roof along the face.*

By preventing the falls of roof along the face the formation of those cavities is also prevented which are both difficult to ventilate—requiring brattice cloth—and to which gas naturally drains. It was the difficulty of dealing with these cavities that became apparent at the enquiry into the

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Clifton explosion in 1884, and together with that disaster led to the change from candles to lamps in the neighbourhood. The importance of ventilating the goaf in the neighbourhood of the working places or of using lamps attracted public attention, and lamps were chosen—by the masters, it is only fair to say, but not by the men—and I do not say as the alternative which could dispense with the apparently more costly ventilation, but only remark that the system of working was not changed.

The change of system, however, was in progress at Ladyshore, and the absence of the dangerous places was and is thought better than the use of lamps to guard against them.

Recent explosions.

As bearing upon the subject the main facts in the nine most recent explosions in the district are instructive.

These occurred at Haydock (two), Atherton, Unity Brook, Altham, Clifton, Bedford, Hyde, and last at the Pendwll Pit, Wrexham. The system was in all of them that of narrow work, with the exception of Clifton, where it was a "cross" between that system and long-wall. In none of them were the goaves packed at all except at Clifton, and then to the extent only of 30 per cent., and in this case that 30 per cent. consisted only of walls three yards thick, possessing comparatively slight powers of resistance.

The ventilation in all the cases was insufficient to meet the circumstances that arose, and in five out of the nine—Haydock (two), Atherton, Bedford, and Wrexham—lamps were used exclusively.

Whether the above circumstances that arose were such as could not have been anticipated, and whether provision against them was obligatory or not, were questions for the coroner's jury, who in all the cases decided that the catastrophe was accidental. It is worthy of remark that in

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none of the cases was evidence sought or tendered as to the measured amount of ventilation—measured, that is, as distinguished from simply described as good or fair—maintained in those places in the mines in which the explosions were supposed to have arisen.

To this absence of enquiry it is due that small light has been thrown on the question of the minimum of ventilation necessary—not only in the main currents, but in any working place—regulations on which head would be much more effective than on general averages.

Measurements of main splits of air at the entrances to districts were in some cases given, but the existence of places in the vicinity of the supposed seats of explosion, in which the air was probably stagnant, and where gas could have been harboured, was ascertained to have been a feature in all the cases but those of Unity Brook and Altham. In these two cases "blowers" were found, which continued for several months. At Unity Brook the blower occurred on the first weighting of the wide work, and at Altham at a fault in narrow work.

It is suggested that in all mines, where the system is "long-wall" and the goaf is packed well to the extent of only 75 per cent., none of the circumstances characteristic of these explosions will ever be found. It is believed that no outbursts or explosions have occurred under these circumstances, and that this system affords greater safety from explosion than does the use of lamps in narrow work or near a partially stowed goaf.

History of the system at Ladyshore.

The absence of hard building material at Ladyshore prevented the building of ordinary pack walls, and recourse was had about thirteen years ago to an experiment in the Trencherbone mine with "gobs" of soft material, supported

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by props and planks, about five yards square. It was soon found when the timber gave way under pressure of the subsiding roof, that the small and soft stuff stood well by itself—just as does sand—when the sides had formed a slope of about 1 in 1.

This led to an experimental place in the Doe mine, 30 yards wide, being carried up 100 yards, leaving unstowed only the air-way and the jig-brow. This was done without a fall of roof, which under the former system of a 3 yards pack in a 10 yards place fell on the taking of every row of props, and frequently before it was wanted.

The extension of the system to the other mines led to the abandonment of narrow work and the adoption of the long-wall gradually, from a series of banks, 25 yards wide, following one another, to the maintenance of a face as nearly as possible in an unbroken line.

The cost.

It was feared that the cost of the system, which at once improved the conditions of the workings, when it was tried, would prove prohibitive, and that the supply of dirt could not be maintained. These fears have on boths heads proved groundless.

The underground wages affected by the system have been reduced gradually (not the rate per man, but the wages item) from 12½d. in 1876 to 9½d. in 1888. Of this cost the packing stands at 4d. This includes all the dressing of roads and roof-ripping—the debris from which, if it had not been stowed, would have had to be sent out. The actual stowing of the material jigged up to the "face" does not exceed 2½d., even where so much has to be imported as to half fill every tub.

Add to this 9½d. the colliers piece work for getting and filling 20d., 3½d. for conveyance to the pit eye and winding,

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and with 5d. for surface wages, we arrive at the total wages cost of 3s. 1d.

The props are nearly all left standing, yet the prop-wood item scarcely exceeds 1⅛d. a ton.

Prop-taking abolished.

The danger of prop-taking is the greatest which the pitman encounters. It is probable that this practice would not be permitted by any colliery firm with whom the men insured their own lives and injuries, as they do now with outside societies, that have no control over the work. This insurance of men with their own employers is required by law in Germany.

Leaving the props enables the packing to be kept up nearer than it otherwise would be to the face, as the props of the back row could not be withdrawn when half buried, let alone being generally splintered and bent up at the foot.

Details of the Ladyshore Colliery and the system of goaf-stowing there carried out.

The six mines worked are the Black and White or Lower Three Yards, the Gingham, Doe, Five Quarters, Trencherbone, and Cannel.

The inclination varies from 0° to 30°, or 1 in 1¾. The thickness of coal varies from 13in. in the Cannel to 6ft. in the Trencherbone, and the length of props to 9ft. 6in. in the Trencherbone.

The stalls or lengths of face served by each jig-brow or gate-road, are 50 yards wide. Cross-roads are left at intervals varying from 50 to 150 yards, and there are occasionally air-ways. These roads will together account for about 12 per cent. of the area of the mine.

The inter-stratified "dirt"—besides filling its original space after being broken up in the getting of the coal—is

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sufficient to stow a proportion of the coal space varying from 4 per cent. in some parts of the Trencherbone (where the coal is 6ft. and the dirt is 6in. thick, and when the "clod" on the coal can be kept up by the props) and 14 per cent. in the Doe (where the props average 7ft. 4in. and the coal is 5ft. 9in.) to 25 per cent. in the Gingham (props 6ft., coal 4ft.)

This calculation is based on the assumption that a fall of "dirt," when broken up, occupies one and a-half times the space from which it falls, inasmuch as this is about the proportion existing between the weight of a full coal tub and that of the same bulk of solid coal.

Thus from 84 to 63 per cent. of the space occupied by the coal remains to be filled by imported or foreign material.

Let us take the first of these proportions and see how it squares with the tubs of dirt sent in and the balancing power.

The coal breaks up, as was said, into $\frac{2}{3}$ its bulk when solid—therefore 84 per cent. of the bulk when solid will be $\frac{2}{3}$ of 84 or 56 per cent. of the bulk of the coal in tubs, which has to balance the dirt up hill.

The dirt, however, is $\frac{3}{2}$ the weight of coal on the average, and $\frac{3}{2}$ of 56 = 84 again. This leaves only 16 per cent. for balancing. But $\frac{2}{3}$ of this imported material consists of cinders, which are only about half the weight of the "mine dirt," so that the total weight to be jigged up is half of $\frac{1}{3}$ plus $\frac{1}{3}$ this percentage of the weight of the descending coal, or $\frac{1}{3}$ of 84 = 67 per cent.

The cinders are thus seen to relieve the jigging of 84–67, or 17 per cent., where they form $\frac{2}{3}$ the material "imported," and in the part of this mine, where the natural dirt is in an exceptionally small proportion.

The proportion of cinders can be altered to suit the difficulties of jigging, the extreme being when nothing but

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cinders is imported, the weight in that case being ½ of 84, or 42 per cent.

These calculations are given to shew that even figures refute the often made assertion that filling up the old works is impossible.

In practice in the Doe and Trencherbone all the tubs are sent in half full, and in the Gingham three out of four are one-third full—every fourth tub being empty.

The use of the spur wheel jig in every place working to the rise is the key to the system.

The cinders are not an essential feature of the system, but it happens to be more convenient to some users of the coal to return their cinders into the canal boats than to cart them to a distance. At present they form about two-fifths the material jigged up the face, and are sent where the balancing power is the least.

Effect on subsidence of surface.

Under compression this packing material cannot probably be ever reduced to its original bulk, and the settlement of the strata—thus supported by a fully stowed goaf—can never amount to one-third the height of the strata disturbed, or, we may say, to one-third the length of the props. In flat mines this proportion will have to be increased to make allowance for the influence of the greater difficulty of stowing the pack full up to the roof.

Ventilation.

The facilities afforded by the system for maintaining air-roads have much improved the former ventilation.

The furnace uses fresh air—is 180 yards from the surface, or half the depth of the pits—and burns 7½ tons in the 24 hours on 48 square feet of grate. This consumption

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can be raised to 10 tons, but the destruction of the brick-work increases in a greater ratio. By the use of an arch 10 yards long, forming a combustion chamber, the smoke is much reduced.

There are three downcast pits, 9ft. diameter, and one upcast, 12ft. diameter.

The water-guage is ½ inch at the furnace, and 1½ inches at the pit bottom.

There are eight main splits of air, all separating at the pits.

Measurement of the air taken at the top of the upcast every 15 minutes for seven consecutive days and nights shewed an average volume of 160,000 cubic feet a minute, ranging from 120,000 to 240,000, the average temperature being 150° Fahr. at the top of the upcast.

Roughly speaking, every degree gives 1,000 cubic feet a minute, and a record of the temperature is now considered a fair indicator of the ventilation, and an efficient check on the work at the furnace.

The margin of ventilation is ample, and a day's stoppage of the furnace for repairs of arching can be made any time, and is not reserved for the week end.

A small furnace burning 30 cwt. in 12 hours at another mouthing is used on those occasions in warm weather.

The pit set of 270 men get 500 tons a day, and the above ventilation is thus 666 cubic feet per man, and 360 per ton.

I have stated the underground wages in the hope that other members will give similar information, so as to enable us to form an opinion as to the economical applicability of the system to all mines—independently of its bearing on accidents. The possibility of such a separation is due to our system of insurance.

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Naked lights.

Besides effecting a reduction of the former cost of 3d. a ton for the owner, this system promises to confer a benefit on the men, which cannot be measured by a money standard, but in so far as it improves the actual work is estimated by them variously at worth from one to two shillings a week—say from 4 to 8 per cent. on an average weekly wage of 25s. Appearances of safety, supported by the foregoing considerations, induced the management—in deference to the wishes of the men—to permit a continuance of the use of open lights after the general substitution of lamps in the neighbourhood.

Only the pitmen amongst us who have used both can duly appreciate the great store set on their candles by pitmen at their work.

These will admit that lamps worsen the work in most mines, increase the danger in all thick ones, and to a degree increasing as that thickness increases.

Where lamps have always been regarded as the proper substitute for plenty of air, the objection by the men to their exclusive use where the air is plentiful, and the conditions on which that plenty depends are both unlikely to vary, and are incidental to the system pursued, is not unreasonable, and to those who perceive force in the claim to safety of a system not dependent on lamps, it may not seem unreasonable in a manager to share the men's objections.

It is neither good engineering nor good political economy to shackle industries.

The lamp is a shackle on the coal getter, that is scarcely denied except in degree, while to a manager it gives great freedom. That it saves him the taking of many precautions, the observance of which would often interfere with his

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meeting the fluctuating demands of the market, will be generally admitted.

Where less air is required for safety, the less will be spent in providing it, and the sanitary condition of the mine must become worse.

The danger from "falls" is increased by any lessening of the amount or handiness of the means of detecting the signs of those impending, but to this the management is not exposed, at least to any comparative degree.

Is it to be wondered at then, if opinions differ, where interests clash, and that a lamp should be preferred by masters and managers who may avoid by its use the consequences of mistakes and false economies, and that the men should call for the best and handiest light, and, in order to make that light safe as against explosion, and economical to the management, either more inspectors, or—a better alternative—such an insurance with their employers against accidents, instead of with societies, as would combine and make one of their opposing interests.

Insurance of employed with their employers.

When employers generally—not in the coal trade alone—take over from the accident insurance societies their pecuniary responsibility, the bearing of a question of economy on the prevention of accidents will no longer be distinct from its bearing on profits; but, till that time comes, the pressure of popular legislation will have to be depended upon for all that can be done in the way of making precautions remunerative.

When, however, that responsibility is assumed or imposed—and it would be no hardship—the prevention of accidents will be subjected to the same powerful motive that sets the industrial and commercial world in motion, and keeps it going.

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This is a stronger motive than fear of the inspector, though that goes a long way, and the insurance rate now paid by the men to their own societies—without the master's contributions—is sufficient to meet all the calls on the present moderate scale of allowances, and would yield a profit to meet precautionary expenses.

The capitalised value of the relief afforded in an average fatal case is £200. Feelings of humanity, however strong in the holder of the purse or in the director of the work, cannot fail to be powerfully assisted by the deposit of such a stake.

Twenty-five per cent. of the insurance premiums is now paid by firms to induce contracting out of the Employers' Liability Act on the part of the employed. It is by about the amount of this payment that the Permanent Benefit Societies funds annually exceed their outgoings.

It must be obvious that, if the chance of being successfully sued for the results of accidents, in which negligence is proved, is worth 25 per cent. of the disablement allowances, liability for the whole of those allowances would be worth many a careful thought, and many a precaution, which at present seems too expensive, only because by it there is no saving to be effected in a contribution, the amount of which does not depend upon the accidents occurring under the firm that makes it.

If, by taking thought, employers can reduce the accidents, they may save the 25 per cent., and the amount, by which the reduction of accidents lessens the outgoings—less the cost of such further precautions as may be taken—and the men, while paying the present rate for insurance, will be more than repaid by the difference between their accident-pay and the wages, earned in health, that replace it.

The masters could insure each other, and many would do, but the differential rates which they would establish to meet

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varying averages of accident due to circumstances, and the recognised danger of various practices and the absence of precautions would, just as in the case of ordinary fire insurance, stimulate improvement in order to reduce the rate.

Any deficiency of security for the existence of funds to meet great catastrophes by individual firms, uninsured with their neighbours, would be more than balanced by the tendency to prevent those disasters, and a bankrupt firm could but send the hat round for their own relief, as is now, and always has been, done for the sufferers.

On the motion of Mr. J. Dickinson, seconded by Professor Boyd Dawkins, the thanks of the meeting were given to Mr. Fletcher for his paper.

The PRESIDENT said, there is no doubt that the subject was a very important one. The long-wall system of working mines seemed to be the prevailing system in this country, modified here in Lancashire; but Mr. Fletcher's idea of filling up the old places he thought must be costly. But he has not given us the cost yet; perhaps he would kindly do so.

Mr. FLETCHER: There are some gentlemen here—Mr. Saint and Mr. Winstanley I think—who have seen the workings referred to in the paper, and I should very much like to hear their observations, especially as to cost.

Mr. SAINT asked what Mr. Fletcher's object was in bringing forward the paper, was it to show that the practice of goaf stowing was new, or that a new system had been introduced at Ladyshore Colliery?

Mr. FLETCHER: The object of the paper was to get the statements and reasoning criticised by the Society for the benefit of those, who trust to packing, and the ventilation

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it induces, rather than to lamps, and the system of working common in the country. Also we,—very rash people,—at Ladyshore wish to put ourselves right with the public, who regard shyly, an isolated practice, till it has been endorsed by experts. The combination of steepness, thickness, and complete packing is, I think, a new one. The old practice was to drive levels every twenty yards and pillar back in ten yard places, building a three yards' pack wall, drawing the props, and depending for the building material upon what falls on the drawing of those props. I believe that to be a more dangerous system of working than the present. When the roof is strong and does not fall, the packing cannot be kept up for want of material, and to blow down the roof in order to get it, is possible, but dangerous and expensive. Places are (thus occasionally) carried too far in advance of the pack, and become liable to fall up suddenly and to seriously check the general ventilation. Evidence of its novelty is afforded by the exceptional use of the tackle required for it. The empty tubs bring up the bulk of the material for packing, and in order to get up a tub half full of dirt against a tub of coal going down, you must have hand winding power given by spur wheels to provide against the occasional loss of balancing power through over-filling of dirt-tubs, unevenness of road, and change of dip. The mines vary in dip from flat to one in one-and-three quarters to 30°.

Mr. Saint: As I understand Mr. Fletcher, he brings dirt from the surface, and puts it in the goaf by manual labour.

Mr. Fletcher: Yes.

Mr. Saint: I do not think there is any particular novelty in taking material down from the surface to put in goaves, for I know several instances where quarries are used expressly

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for the purpose of getting material, but not in steep mines—only where they use horse power in drawing tubs running along the faces, the tubs being used to take down their material, and bring back coal.

Mr. FLETCHER: Cinders are the only material taken down. They are light, easily moved and stowed, fill up interstices well, and the labour is paid for by customers at a rate which is less than their cost of disposal. £108 was paid last year for the canal tonnage and discharging of the cinders. Material, now taken to the working places, would otherwise have to be sent out of the pit, and would there form heaps of debris and become a nuisance, occasionally on fire, and always an eye sore.

Mr. HALL: How many tons a day do you send down from the surface?

Mr. FLETCHER: At present about 100 tubs full a day, weighing about 7¼ cwt. each.

In answer to a question by Mr. Hall,

Mr. FLETCHER said they sent their own cinders down, and those of such customers as found it worth their while to place them in the empty coal boats. It was obviously a convenience to many a coal user to empty cinders into coal boats instead of sending to a distant tip. They could do without those cinders, constituting as they did only 20 per cent. of the amount of the imported material.

Mr. WINSTANLEY: Will you give us the cost of the packing?

Mr. FLETCHER: I wanted Mr. Winstanley to say something about the disadvantages of leaving the props. I am sure it would have produced an interesting discussion.

Mr. FLETCHER then read a statement as to the cost of packing, which is embodied in his paper.

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Mr. WINSTANLEY: Is not a large portion of that reduction in cost due to the change from pillar and stall—saving the yardage of the narrow work?

Mr. FLETCHER: Obviously; not only is the first driving of the narrow work saved, but its maintenance also, which exceeded that of the pack roads, and the prop-taking to obtain the building stone, its breaking up, carriage to and arrangement in the pack walls, is also saved, the present work being nearly all done by spade.

Mr. WINSTANLEY: There are mines where this system has been practised for years and years, the whole goaf being stowed not with material brought down from the surface, because there was not room for it, but every ounce of debris made in the mines has been packed in the goaves and in the disused roads; and not only that, but hundreds and thousands of tons have been brought to the surface. Iron mines are being worked on the same system, that you are working now—that is wide work—as they have sufficient dirt to pack the goaves without taking any down from the surface.

Mr. FLETCHER said he had seen something like the same thing in Wales, and also in Belgium; but in South Wales the mine was flat, and in Belgium it was thin, and in both, the roads were very frequent—about every 15 yards—and the strength of the packs, therefore, much less. All he wished to convey was that it was new in his own district, and in thick and steep mines, and that explosions had not occurred where it had been practised.

Mr. DICKINSON: I would like to say in discussing this question that it should be clearly understood Mr. Fletcher is dealing with the thick mines, namely, from five feet up to ten feet which have not hitherto been stowed tight, but only with pack walls and spaces between the packs, and it is the filling up of those spaces in thick seams, as Mr.

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Fletcher is filling them up, which is something new in such seams, although it has long been done in the thin seams. By general tight stowing, Mr. Fletcher has kept his colliery from some of those sudden subsidences which one sees in other places, and has his faces of coal standing much more solidly; and probably he is getting a larger proportion of round coal, and the air-ways do not need the same repair as they do where the whole surroundings are on the move. Mr. Fletcher's system of leaving all the props behind, or most of them, is certainly not generally practised, and if you go over the list of accidents, fatal and non-fatal, you will find a long list of prop-takers are killed while in the act of taking them. Mr. Fletcher avoids that risk, and his cost of timbering, 1½d. per ton, is certainly small. Mr. Fletcher, in the title of his paper, speaks of goaf-stowing "in its effect on ventilation;" but he has not told us much about that. I do not think there are many who will support him in his view of working with open lights in fire damp mines. All those who are using candles are getting whipped up, one by one, into the use of lamps, and at the same time the subject is being carefully watched, in this district, as to the effect that the introduction of lamps in place of candles will have upon the number of accidents by falls of roof. A poor light has always been put forward as being likely to cause a great increase in the number of accidents by falls. Possibly it may; but we may expect to more than counterbalance it, by the saving in the number of accidents from explosions.

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THE PHŒNIX PATENT SAFETY LAMP.

Mr. GEORGE H. HOLLINGWORTH exhibited the lamp and read the following description of it:—

The lamp now exhibited is the design and invention of Mr. William Clifford, of Sheffield, a member of this Society.

It is certainly, whatever its merits, a new departure in lamp construction, and the inventor invites criticism with a view to improved construction and to the obviation of the lamp's defects in future.

The cost is about 6s. 6d. per lamp, in crucible steel or stamped brass. Firemen's lamps, with telescopic tube, 1s. 6d. extra. Its weight is 2½ lbs., and it is guaranteed not to fire when exposed to an explosive mixture moving at the rate of 75 feet per second.

I have had no experience in using the lamp and in fact saw it for the first time this morning. The lamp exhibited is a crude form and several of the details will be improved upon in future constructions.

The inventor says the lamp is designed to be handy to clean and use, and the gauze being removable only when a new one is required, it cannot therefore be left out by a careless lamp man or examiner.

The light from the lamp is shed upon that part of the roof directly over it and cylindrical glasses may be used without materially sacrificing this property.

The lamp is safer in explosive mixtures at high velocities than any now in common use and will be guaranteed at say 75 feet per second.

The shield at the back is cool when the lamp is otherwise hot and can be used as a handle in trying for gas.

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For firemen's use the lamp will be provided with a tube fastened to the back of the shield communicating at its lower end with the inlet. Another tube telescoping within the first can be raised above the top of the lamp in trying for gas in small fissures. By turning a button the lamp will receive the whole or part of its air supply through this tube at the fireman's pleasure.

A scale of percentage values of flame elongation might be added at the back of the glass.

For special examinations it is intended to make the lamp without a loose glass, a trumpet mouthed front with a bull's eye glass of proper curve, and a rectilinear reflector, allowing the whole effective light of the lamp to be concentrated upon a limited field.

The thanks of the meeting were given to Mr. Hollingworth on the motion of Mr. Stirrup, seconded by Mr. Winstanley.

The annexed drawings will explain the construction of the lamp.

Fig. 1 is a vertical section; Fig. 2, a transverse section upon the line AB; Fig. 3 is a plan of the oil vessel and attachments, with the upper portion of the lamp removed. A glass cylinder surrounds the flame, and is firmly held in position by asbestos washers. The upper portion is contracted in diameter, and is covered by a metal hood, which forms part of a segmental pillar or box E, cast in one with the base portion F, or attached to it in any other substantial manner. This base is fitted tightly against the oil vessels by means of the shackle hinges L and O, which are of special construction, and jointed in a thoroughly safe way. The gauze is a flat sheet G, bent to fit the segmental portion (fig. 2) of the box pillar E, and protected by the shields or bonnets C, H, K. The main bonnet C hinges at D to the pillar portion E, and when unhinged the gauze is open for inspection and cleaning, if need be. The gauze is forced between the segmental surfaces of the bonnet and the pillar E.

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The action is as follows: When lit, the oil vessel is safely fastened in position by the shackles or yokes, and the air supply

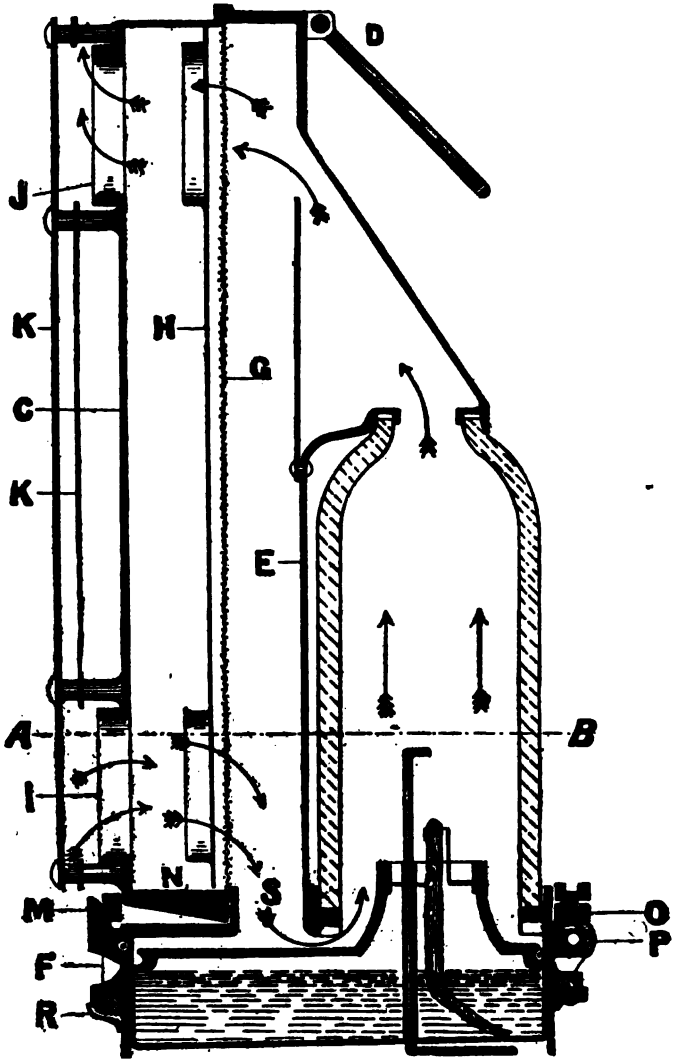

FIG. 1.

enters the bonnet at a passage I, which is shielded by a metal plate K. It then finds itself in a space within the bonnet, but

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still separated from the gauze by the internal shield H, which has two apertures opposite to I, but not in direct line with it. The air reaches the gauze by these apertures, and passes through it into the space S; from thence it flows under the glass by the annular

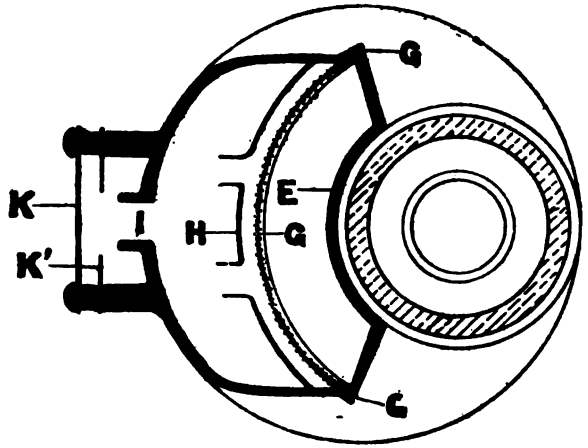

FIG. 2.

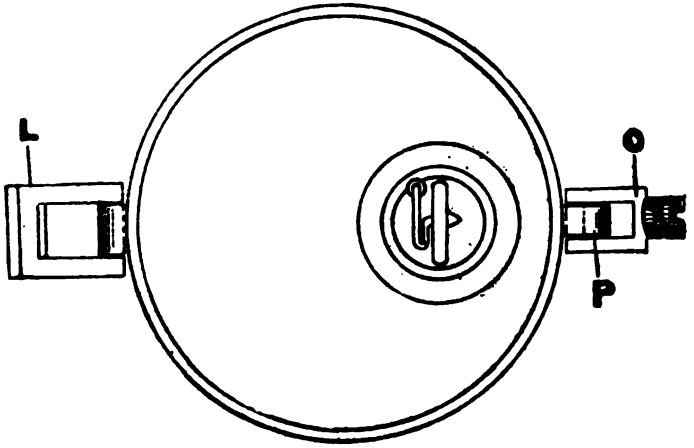

FIG. 3.

space shown, and passes upwards to the flame to supply the combustion. The hot products then ascend, and flow out at the top of the glass by the hood into the upper portion of the space enclosed

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between the gauze G and the pillar E; then, as shown by the arrows, through apertures in the shield H and the passage J in the bonnet C, which is protected similarly to the air inlets. By this method the light from the flame is free to strike upwards with but little obstruction above, and although the air supply is from below the flame, the gauze is not placed under the wick, and is free from chance of clogging by spilling the oil. A plentiful supply of air thereby enters the lamp, and it is not sensitive to tilting or movement. The complete arrangement of shields and bonnet prevents the possibility of any current of whatever velocity from impinging directly upon the gauze, and thereby renders the lamp safe in explosive currents.

The shackle L is made with an inclined face to press against the projecting inclined piece or wedge M, so that when closed by hinging from R the portion N of the bonnet will be firmly pressed against the gauze to make a joint. The gauze may be fastened to the segmentary edges of the box E in various ways, but in any case it is exceedingly easily got at for inspection. When the yoke O is slipped over P, it may be strained up by screw or fastened with a lead rivet.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, April 9th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOHN KNOWLES, M.Inst.C.E., in the Chair.

COMMUNICATIONS.

The HON. SECRETARY (Mr. Stirrup) said he had received a circular addressed to the Society from the Ministry of Commerce and Industry, Paris, with regard to the proposed International Congress of Zoologists which was to be held in the French capital this year in connection with the Exhibition. It was an invitation to the Society, or any member of it, to take part in the proceedings of that Congress in the month of August next, by the offering of papers on subjects pertaining to zoology. This invitation, Mr. Stirrup said, was no doubt one of a series of like character which would be addressed to most English societies of any repute by the principal French scientific societies, holding Congresses in Paris, who were desirous of showing international courtesy.

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The only part of the programme of the Zoologists' Congress, it seemed to him, which came within the scope of their Society, was that bearing on the relations existing between the actual and fossil faunas. It was open to any member of the Society, on payment of the subscription mentioned in the circular, to attend the meetings of the Congress, and take part in the discussions.

A NEW ARCHÆOLOGICAL DISCOVERY ON THE SHIP CANAL AT STICKING ISLAND.

By Mr. Charles Roeder.

It was first my intention to offer a few details about some sections of the Ship Canal and various observations I have made from Throstle Nest point down to Warburton, but I am afraid I cannot compress my remarks sufficiently to make it worth while to present them at this last moment, and I, therefore, beg to place before you merely another discovery, having archæological interest, which I made on Saturday last while examining the Barton section.

The leaf-beds rest on the coarse gravels and the latter directly again on the floor of the Trias, which bears the most striking evidence of moraine and glacial action, in the shape of deep channels and bosses, traceable straight along from Mode Wheel, where these beds break out. The leaf-beds have been already made the subject of examination and discussion, attention being first drawn to them by Mr. Leader Williams, at the meeting of the Society at Owen's College in January last, while Mr. Thomson has since given a list of the plants and trees which gave rise to them, and subsequently they rose into further eminence by the discovery on Wednesday last of an ancient canoe, found in the same horizon. It would be difficult yet to affix any age to which this relic of early civilisation has to be referred. Another similar canoe has been, as is already known, found

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during the Ribble navigation excavations at Preston, and it would be well to see what co-relation there exists between them, and if the geological evidence shows any similarity of deposition, and if there is a structural relation. Also, if the canoe discovered some time ago near Peel, Isle of Man, falls into the same category. Until we have some better data it is a mere pretension to speak of Pre-Roman with reference to the age of the canoe in question. It may be pre or post. Meanwhile a very careful search may help us on, and yield collateral finds to fix a securer basis for a probable period. So far we have been less fortunate than Preston with its immense finds of the former fauna; what little has been discovered on the canal section consists, it appears, of some antlers from near Warburton. I have looked so far in vain from Old Trafford onwards for any stone-hammers, flint tools, whorls, or skulls and bones, but, as a compensation, found in the same silt and leaf-beds at Sticking Island, as above mentioned, another article, namely, a wooden comb, which I beg to place before you for examination, and now proceed to describe. It is 3⅝in. long, 1⅛in. high, and ⅝in. thick. It has teeth on both sides, the upper narrow row has been, it seems, destroyed by the action of fire. Its indentation is 2¾in. long, and had, when complete, about 55 teeth, the under row still bears 8, entirely preserved teeth, at the origin ⅛in. thick, cut to a point and nail-shaped; the edges are not sharp, but all angles cut away, each tooth measuring 1⅛in. The two ends of the comb are curving down, the wood used is of a soft nature, and does not appear to be oaken; the comb is perfect and not in any way injured with the exception of the upper teeth, which, as said before, are destroyed by fire. Neither is it sculptured, pierced, or carved, but quite smooth. Wooden combs are very rarely found, most having perished, as a consequence of the easy destruction of such small articles, of material so

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easily decomposed. Combs of bone and ivory have been now and then found in British and Anglo-Saxon barrows, as for example at Barrow Furlong, Northamptonshire. The Irish rack combs are different. We have also the double comb, mentioned in the "Inventarium Sepulchrale," and the mane-combs, which, as the "Shuttleworth Account" tells us, cost, anno 1616, 4d., and a single curry comb 6d., a double 1s. 6d. So far, then, the excavations have brought up a canoe, a quern, and a wooden comb, and we hope that our list may be swelled further. I may, perhaps, be allowed to add a word and a plea for these valuable finds. Unfortunately Manchester is deprived of the blessing of an archæological museum, that is, a place specially and essentially devoted to the preservation of historic and prehistoric relics and monuments, and in this regard stands behind other towns, much to our grief. The consequence is that many prehistoric and historic articles of the greatest value become lost, or scattered, or go away. Owens College, as I know to my own cost, treats these things but indifferently and step-motherly, and they appear to be admitted on mere sufferance; the new Museum, so far, has not made preparation or granted any facilities and space for such finds, and it is time to ask if we must look quietly on and let things *laisser aller*, or obtain some proper and prompt concessions and assign a permanent home in the College or elsewhere for these relics, illustrative of our county, and which we can ill afford to forego.

A vote of thanks to Mr. Roeder was passed on the motion of Mr. De Rance, seconded by Mr. Stirrup.

Dr. BLACK said he had the pleasure of seeing the other day the canoes found at Preston, during the excavation for the Preston works. There were two; one was in a good state of preservation, the other somewhat damaged. In

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reply to the President, Mr. Black said he had examined the comb described by Mr. Roeder, and had no doubt it was of wood, as stated.

Mr. STIRRUP pointed out the great similarity of the comb to one figured No. 473 in "Jewitt's Grave Mounds and their Contents," which he handed round for inspection.

Mr. DE RANCE said he had had the opportunity, under the guidance of his friend Mr. Sykes, the Engineer to the Preston Dock Works, of going through the extensive cuttings, in which the two vessels referred to by Mr. Black were found, a district he had previously examined for the Geological Survey, he also had geologically examined nearly the entire district through which the Manchester Canal is carried, and since the commencement of the works had visited the Canal from time to time, to see whether any new sections were exposed which, in keeping the maps up to date, it might be important for the Survey to record. He had the opportunity, a few weeks ago, of examining the place at Barton where the canoe was found; but it seemed to him that, as stated by Mr. Roeder, there was at present no evidence of the date of that and other recent discoveries—that was to say, no historical date. In the valleys of the Wyre, Ribble, and the Mersey, he thought they had sufficient evidence to conclude that the horizons, in the different localities, belonged to one period. In the year 1847 a very interesting discovery was made near Rossall Land Mark, Fleetwood, there were found in eight feet of yellow clay a large number of Roman coins resting on beds of peat, and the explanation apparently would be that the Romans, slipping upon the soft mud—the levels being pretty much as they are at the present day—had the misfortune to lose their treasure chest. A very large number of coins were found, the soldiers probably effected a landing on the peaty shore, and those coins were lost on the top of

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the peat. The peat was very well seen on the shore near Rossall, and roots of Scotch fir were found in the boulder clay beneath ; therefore it was obvious that the peat in that particular place was older than the Roman epoch, because the coins were found resting upon it. Traversing the district in the direction of Lytham and Freckleton in the Ribble Estuary, you again come upon the peat occupying a similar horizon, and near the latter place there has been found the remnants of a Roman bath, at the same level ; these facts show that the country had not risen or subsided materially since the days of the Roman occupation. In the valley of the Ribble, is a low level alluvium of which the upper portion consisted of laminated silt resting on peaty beds, with fragments of trees, below which is a coarse gravel containing the skulls of various mammalia, which were known before the Preston Dock Works were commenced. Since the dock works had been carried out that peaty horizon had been found to extend towards Freckleton, and there, various mammalian remains were found in the massive coarse gravel which underly it. They might follow that peaty horizon mile by mile, from the mouth of the Ribble towards Southport, till they found, near the latter town, a great bed of peat 25 feet in thickness. The connection between that peaty horizon which lay beneath the alluvial silt of the Ribble and the peat beds near Southport and thence by Formby to Seaforth, was distinctly traceable. Then, crossing over the Mersey, they found the same order of things in the neighbourhood of Dove Point, and the entire coast. On the shores of Wirral, between the mouths of the Mersey and the Dee, there had been discovered a wonderful assemblage of antiquities, described with great elaboration by the late Dr. Hume, dating from stone arrow heads and implements, and coins of Edward the Confessor and William the Conqueror, down to the reign of Queen

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Victoria. They were partly remnants washed out of old deposits, and partly objects thrown up by the sea; but they arrived at this special fact that there again, wherever Roman remains could be identified, they were found either on the surface of the peat or in such situations that they appeared to have fallen through the peat by their own gravity. The stone implements that had been found were of Neolithic type, many were preserved in the Liverpool Museum. In Wirral the evidence seemed to be the same, that the main peat was just about stopping growing at the time the Romans came to this country. The stone implements appeared to be somewhat older. Applying these facts to the valley of the Mersey, it seemed to him that the gravel deposits which were so well exposed in the deep cuttings of the Manchester Ship Canal, belonged in a general way to the same epoch as the low level alluvium of the Ribble. Beneath that were trees which probably, in part, grew in the situation in which they were found. When he was last at Barton, a few weeks ago, there appeared to him evidence of such having been the case. The trees, it would seem, were unable to grow through obstruction of the drainage; they rotted, and were eventually blown down; then came a flood which first cleared out the obstruction, and subsequently left the alluvial gravels, as it had left the alluvial silt in the valley of the Ribble. He was inclined to think that all those different connecting links of evidence told one and the same story—that was, that the country had changed very little since Roman times, and that immediately before the Roman occupation there were ancient Britons, or some other ancient people, using those very interesting vessels.

Dr. Black said the canoes he saw at Preston had evidently been carved out of one solid block of wood. They were half canoes, square at the stern, each apparently being

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designed for a single occupant. At the bow, or stem, there was a hole, not above the gunwale, but below it. It might have been designed either for mooring the boat to the bank or for towing. It could scarcely have been a provision for anchorage. This was a peculiarity he had not previously noticed. In the same deposit were found very interesting animal remains—skulls and horns of cattle and deer, all in remarkably fine preservation. These were to be seen in the museum in Winkley Square, Preston. There were also some human skulls.

Mr. De Rance said the human remains from the Preston Docks were, he believed, in the silt above, and were not so old as those of the mammalia found in the gravel below.

Mr. Stirrup asked if Mr. De Rance had seen the leaf-bed, a sample from which was exhibited at the Owens College meeting of the Society by Mr. Leader Williams?

Mr. De Rance said he had seen the peat-beds at the spot, but not since the discovery of the leaf-bed.

Mr. Stirrup said the peat beds on the Lancashire coast seemed to be in a much more decomposed state than the leaf bed found in the Barton cutting. Some of the leaves were green, and there was no difficulty in establishing their identity.

Mr. De Rance said the deposit he saw at Barton was a mixture of leaves and peaty matter, with twigs, hazel nuts, &c., in the condition which they often saw in peaty beds, but they were certainly not so much decomposed as the peat beds of West Lancashire. That was not to be expected when they were covered over with gravel.

Mr. Stirrup said he had not yet seen the Barton canoe, but from the description and figure of it given in the *Manchester Guardian* it was of the type of most of those dug-out canoes which had been found under similar circumstances in various parts of the country.

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In answer to Mr. Burrows,

Mr. STIRRUP said the canoe, he believed, was found in the same horizon as the leaf-bed. The comb found by Mr. Roeder also, he understood was from the same locality.

Mr. DE RANCE asked if it was correct to say that the leaf-bed was found below 25 feet of gravel?

Mr. STIRRUP: It was beneath a bed of sand and 20 feet below the surface.

Mr. DE RANCE: The canoe was found, according to the account in the *Manchester Guardian*, in that peaty bed, with the trees, at a depth of about 24 feet from the surface.

Mr. STIRRUP: Yes, I believe so.

Mr. DE RANCE: It is very remarkable that the leaves should be still green, unless this particular spot has been the site of a river channel of more modern date.

Mr. STIRRUP: The leaves not only retained their chlorophyll, but were so little altered that the species to which they belonged could be readily identified.

The CHAIRMAN said they were in a perfect state of preservation.

ON THE USE OF ROBURITE AND OTHER EXPLOSIVES IN MINES.

BY MR. WILLIAM WATTS, F.G.S.

I endorse the remarks of Mr. Bramall on the use of roburite as an explosive, and regret that I was not at the meeting of the Society when his communication was read.

I have tried roburite in tunnel driving for water-works purposes, and my experience of its use on the health of the men confirms the observations made by Mr. Bramall.

The men complain of pains in the head, weakness in the lower parts of the legs, and a peculiar sensation at the root of the tongue.

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The noxious fumes given off by roburite are nearly equal in volume to the fumes given off by the explosion of similar charges of tonite; but the former appear heavier, and linger in the heading for a longer time. In wider and loftier passages than 6ft. × 6ft. headings, the fumes, however, may dissipate more freely, and with less effect on the health of the men.

Where there is ample circulation of atmospheric air in the workings, more especially after an explosion, doubtless roburite may be used with impunity, but the inflow wants to be such that it will immediately remove the foul air from the working face.

It is not strictly correct to say that roburite gives off no noxious fumes on explosion. They may not be perceptible in experimental trials on the surface of the ground, where the explosive has little or nothing to do, but in confined spaces, and where force is developed, a complete haze is formed extending some distance from the working face.

Some of the haze may be from the combustion of the fuze, but when the shots are fired by electricity the results are practically the same. The more work, however, a powerful explosive has to do the more perfect the combustion, and this fact should not be lost sight of in its use.

In the workings to which I refer, the miners pay for the explosives used, and although roburite is 3d. per lb. cheaper than tonite, they will not again consent to use it. Experience teaches an observing workman what suits him best.

The combustion of roburite appears to me sensibly quicker than tonite, and the reports of the explosion are, I think, sensibly louder; but the time is scarcely measurable, more especially when the observer has to retire for safety about 80 yards from the face of the heading, and when each

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report lingers tremulously on the ears in long drift ways.

Loud reports are no guarantee of effective firing, but generally the opposite. Thus in the oxidation of explosives the silent discharges are the most destructive.

Roburite appears to occupy an intermediate place between dynamite and powder. Taking powder at 1·00, roburite is 2·00, tonite 2·50, and dynamite 4·50, we have the comparative values of each.

These values, however, do not tell the miner much. He learns by experience the various uses to which each is best adapted.

Each compound is suitable for different kinds of work, and the difficulty seems in making the selection.

In mining operations the selection of the shot holes is invariably left to the workmen, who seldom consider where the lines of least resistance are in the rock being dealt with, and the exact amount of explosive material necessary to use in each hole. A knowledge of the ground gives them general ideas, but it so frequently varies in structure, dip of the beds, and character of the joints, all of which render it difficult to determine the exact amount of explosive compound to use. Besides, it makes a difference if the beds lie towards or from the men, also whether there is a blasting floor or not.

For damp and wet headings, roburite and tonite are superior to powder; but where the ground is dry, powder in my opinion is more effective in execution, and cheaper.

It does not shatter the material to the same extent, but it rends and projects it, and it can be used in a modified form, scarcely possible in violent explosives.

In these remarks I am confining my observations to work done in sandstone and shale rocks. But amongst granite,

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and very compact rocks, the violent explosives doubtless may be more suitable, but with those geological formations I have had no experience in blasting.

For blasting in open tunnels, and in engineering works in general, powder will maintain itself in opposition to all other explosives; but in fiery mines, and ill-ventilated headings, it cannot be upheld. As to the chemical composition and mechanical mixtures of the explosives named, I must remain silent.

My object has been to deal with the behaviour, and not with the composition of the compounds named.

I have already wandered beyond my expectation at the outset of this short communication, but the subject grew in interest as I proceeded, and I had a difficulty in restraining myself from further remarks.

It required no little courage for Mr. Bramall to bring the subject of roburite before the Society. Facts cannot for long be withheld, but when they are brought before us by gentlemen of large experience, they are all the more worthy of consideration.

Mr. Burrows moved a vote of thanks to Mr. Watts, which was duly seconded and passed.

Mr. Stirrup suggested that the discussion upon the paper should be left over until the Wigan meeting in May, by which time the communications made by Mr. Bramall and Dr. Bury in March would be printed and in the hands of members.

The suggestion was supported by various gentlemen, and ultimately agreed to.

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FISH REMAINS FROM THE LOWER COAL MEASURES OF LANCASHIRE.

By Mr. Herbert Bolton.

The fish remains now laid before you have been obtained from a bed of black shale 56 feet in thickness, which overlies the Upper Foot, or Bullion Mine of the Rossendale area.*

The shale in question crops at the surface in the left arm of Oakenclough, a narrow ravine to the south-east of Bacup.

Running through the shale bed are numerous layers of ironstone nodules, and solitary ones also occur. It is from the latter that the specimens have been derived, but a number of nodules in the various rows yielded coprolites, and certain biconcave disc-like structures, whose nature I have been unable to determine. Unfortunately, they are very friable and readily fall in pieces.

So far as I am aware no fish remains have been previously recorded from this particular stratum in Rossendale, though fish scales and teeth are fairly abundant a little higher in the series, namely, in the shales which rest upon the Upper Mountain Mine.

Elonicthys Semi-striatus (?)—This specimen has a total length of 12 inches, its greatest depth (2 inches) being immediately behind the head.

The thickness of the body would seem to be considerable in comparison to its depth.

The extremities of the body are strongly deflected dorsally.

The tail is large, the tail fin being deeply cleft, and markedly heterocercal.

The head forms the anterior fourth of the fish.

Skull.—The skull has been subjected to a compressing force, coming partly from the side and partly from below,

* See Vol. XIX., Part X., page 22.

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so that, as it lies in the matrix, only the lower jaw and a slight portion of the left side of the cranium are visible. The dentaries *(d)* are two flattened ill-preserved bars of bone, 2 inches in length, expanded behind and tapering anteriorly.

Branchiostegal Rays *(Br.)*.—The right dentary, an inch from its hinder border, is overlaid by the last traces of the basal portions of a series of narrow rod-like branchiostegal rays, the impressions of four being clearly marked. Faint indications of others occur behind, and extend almost to the articulation of the jaw.

From the rod-like character of the rays and the extent of surface covered by them, we may infer that they were fairly numerous. A strongly angulated bone overlies the dentary of the left side, but no satisfactory determination can be made of it.

Infra-clavicular (?).—Behind the dentary of the right side, and in front of the pectoral fin-ray occurs a triangular-shaped bone, whose precise nature it is difficult to determine.

It occupies the position we should assign to the infra-clavicular, and it may possibly be the hind portion of that element, but the suggestion must carry a doubt with it.

Paired Fins.—These are represented by the pectoral and ventral members of the left side.

Pectoral.—The pectoral fin is supported on strong jointed fin-rays, which split up and become filamentous as their free extremities are reached. It is inserted on a broad base, immediately behind the skull.

The anterior border of the fin is strongly convex, the first fin-ray being a stout unjointed bar, whose base is clad in fulcra, or small overlapping scales.

Ventral.—The ventral fin is placed at a distance of 1 inch from the hind border of the pectoral, and whilst smaller in size would seem to be seated on an equal base.

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Its true size cannot be clearly determined, owing to the margin of the fin being cut off by the edge of the nodule. A portion of the anterior border is concealed in the matrix.

Both pectoral and ventral fins are supported by strong jointed rays, which bifurcate repeatedly at their distal extremities. The joints are straight, and divide the rays into segments a little longer than broad.

Median Fins.—The dorsal fin is for the greater part still buried in the matrix. Its extraction will be a task requiring care.

The basal portion of the posterior half is exposed, and shows the fin to be supported by jointed fin rays, as in the case of the paired fins, but much stouter.

The surface of attachment of the dorsal fin is large.

The hind border terminates about an inch and a half in front of the root of the tail, and the anterior border is almost in line with that of the ventral fin.

The anal fin seems to have had its anterior border in line with the hind border of the dorsal fin, whilst the space between the anal and ventral fins is almost double that between the ventral and pectoral. Very little of the anal fin is preserved, a small fragment of the free margin and a few basal portions of fin rays being all that can be distinguished.

The basal portion of the fin ray furnishes us with some data respecting the size of the fin. Each fin ray is cut up by a series of concave joints into segments a little broader than long. The surface of each segment is black, lustrous, and convex. The fin ray marked * illustrates these features fairly well.

The fin rays have twice the bulk of those of the pectoral, and closely approximate in size to those of the dorsal fin.

The tail fin is very massive, and strongly heterocercal. Its dorsal border is clad in overlapping fulcra, which much

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exceed in size those of the paired or median fins. The fin rays which supported the lobes of the tail are clearly defined, and the border of the fin itself stands out with great clearness.

The ventral lobe is incomplete.

At the root of the tail occur a few interspinous bones, the largest being half an inch in length. They have a characteristic hour-glass shape and appear to be solid structures.

Dr. Traquair speaks of these interspinous bones as being hollow,* but I have been unable to find traces of a central cavity.

Scales.—No scales have been found associated with the remains, so that one of the chief means of determining the species is wanting.

Determination of Genus.—Notwithstanding the total absence of scales a careful examination of the leading structural features is probably sufficient to determine its affinities. With the structural features we have already dealt, and it will be sufficient if we now give a brief synopsis of the leading characters of the genus.

"Body fusiform, rather deep, tail large, caudal fin deeply cleft and inequilobate. Dorsal fin well formed, nearly opposite the interspace between the ventrals and the anal fin. Dorsal and anal fins large, triangular, and supported by numerous closely set and closely jointed rays. Pectoral and ventrals, acuminate, rays closely jointed, except in case of first few rays of the pectoral. The fulcra of all the fins closely set and minute, with the exception of those on the upper margin of the tail fin. Gape wide, branchiostegal rays many, numbering 22 in case of *E. semistriatus*.†

That the form is *E. Semistriatus* and not *E. oblongus* or

* Dr. Traquair, Article "Palæoniscidæ," page 50, Vol. XXI., Palæont. Society Pub.

† Vol. XXI., Palæont. Soc. Pub., page 47, Art. Palæoniscidæ.

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E. caudalis is difficult of proof, it can only be suggested on the strength of Dr. Traquair's cursory examination of the specimen, that gentleman having examined it and regarded it as *E. semistriatus*.

Specimen No. 2.—This nodule contains a portion of the skull of a *Cœlacanthus*, together with a small portion of the anterior end of the body. The ventral surface is uppermost.

Jugular Plate.—The first feature noted on examination is the presence of two triangular plates occupying the whole of the space between the rami of the mandibles. These plates meet in a median suture, from which the hinder border of each departs almost at a right angle. Anteriorly the outer edges of both the jugular plates slope rapidly inwards, and in all probability meet the median suture in a very acute angle. That the whole of the space between the rami of the mandible was occupied by the jugular plate may be inferred from the occurrence of a fragment of the right ramus in close connection with the jugular plate of that side.

There are three points in connection with the jugular plates to which I desire to draw your attention, and to which I shall again allude. First, the right angle which the hind border of each makes with the median suture; second, the acute angle which each outer border undoubtedly makes with the anterior extremity of the median suture; and, thirdly, the absence of all sculpture on the surfaces of the plates. The latter is not a strong point, since they are but badly preserved.

Frontal Shield.—The anterior extremity of the skull has been knocked off and lost, but its absence serves to show the impressions made by two cephalic bones which met in the middle line.

Professor Huxley,* speaks of the roof of the skull of

* Decade XII., Memoirs Geo. Survey, Organic Remains.

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Cœlacanthus as being formed by "a parieto-occipital, and a frontal shield." This being so, I should presume the impressions to be due to the frontal elements of the parietal shield.

Undetermined Bones.—Bounding the sides of the skull are two large flattened bones, with surfaces wholly destitute of sculpture. Whether these bones are part of the occipital shield, or whether they represent the suspensorium, or even some other structure, it is very difficult to say.

I cannot venture to form an opinion upon them.

Body.—The anterior portion of the body shows faint traces of finely imbricating scales. Very little is left of the scales themselves, but from these remains and the impressions, we can gather that they were thin cycloidal scales, having sculpture in the form of wavy ridges.

Dorsal Fin.—At the point where the body is broken off, on the right side of the fish, is to be seen the fragment of a stout spine, which I take to be the anterior spine of the dorsal fin. At its base are to be seen about half a dozen fine striæ which may, or may not, indicate the former existence of fulcra.

So far as I am aware, these are the only features to be made out in the specimen.

The fish is chiefly interesting as showing a wide divergence in shape of the jugular plates, as compared with those of *C. lepturus*, and allied forms described by Professor Huxley in the Memoir already alluded to. In all specimens there figured, the jugular plates do not possess any marked attenuation anteriorly, and they are distinctly sculptured with "delicate undulating ridges which, on the whole, run more or less parallel with the outer edge of the jugular plate, but in front converge towards the inner edge"

In regard to the specimen now before you, I have referred at length to the marked attenuation anteriorly of the jugular plates, and also to the fact that no evidence of sculpture can

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be discerned. Both plates, however, possess a ridge which runs somewhat parallel to the outer border. This can be best seen in the right jugular plate, where the ridge is also seen to have a very slight trend inwards anteriorly.

In the case of the jugular plates of *C. lepturus*, &c., the breadth of the hind border will go several times into the length, but in this case it will only go twice. This would indicate a much shorter and broader mandible than in the case of *C. lepturus*.

Determination of Genus.—The thin cycloidal scales, with their traces of a sculpture made up of wavy ridges, and the presence and character of the jugular plates, I take to be sufficient evidence that the remains are those of a *Cœlacanthus*.

What the species is I am unable to determine.

Specimen No. 3.—This specimen, pronounced by Dr. Traquair to be a portion of a *Cœlacanthus*, consists of a replacement by iron pyrites of a series of overlapping scales, most of which still show traces of sculpture in the form of ridges, which in the better preserved scales run towards a raised central line. The scales are also very thin and cycloidal in character. From a careful comparison of these scales with those of C. *lepturus*, described and figured by Professor Huxley,* we are inclined to think they represent a fish of that species.

Professor Huxley describes the scales as "thin, flat, and cycloidal, the middle of the hind border of each scale being prolonged backwards, so that the exposed portion of each scale is nearly triangular." The scale sculpture consists of raised continuous ridges converging towards a central line, a feature of which Professor Huxley makes special mention.

Specimen No. 4.—This consists of the fragments of a tail fin, in which a few hour-glass shaped interspinous bones

* Mem. Geol. Survey, Dec. XII., p. 16.

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can be distinguished. It is remarkable as showing unmistakably evidences of the notochordal axis in the form of a cylindrical structure. The central portion of the cylinder is now partially filled with a fine yellowish-brown earth.

The notochord does not seem to have been constricted in any way, but to have had a fairly uniform diameter. Posteriorly it ends in a blunt point.

On one side, the interspinous bones are seen to have been in direct contact with the notochord.

This is all that can be made out, the rest of the nodule containing no trace of fish remains.

Specimen No. 5.—This is represented by an irregular mass of small rhomboidal scales, and a few beautifully sculptured bones.

There is no semblance of a fish.

The scales would seem to be very similar to those of *Rhizodopsis*, but they are too small for their characters to be satisfactorily distinguished.

Specimen No. 6 is a coprolite, somewhat elongated in form, and consisting of a brown and greyish earthy mass, in which occur a few fish scales. A few scales are also scattered about in the stone. It is a source of regret to the writer that the specimens now submitted to your investigation have not been better cleared from the surrounding matrix, and also that they are so fragmentary.

Both conditions are largely due to the fact that the occurrence of such remains in that particular horizon was wholly unexpected, and that the blows which broke the nodules were not well directed. I might further add that a very heavy hammer was used.

In conclusion I desire to express my thanks to Dr. Traquair, F.R.S., for his kindness in viewing the specimens, and also to A. Smith Woodward, Esq., F.G.S., of the Natural History Museum, who has rendered much help.

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Mr. Stirrup said he had much pleasure in moving a vote of thanks to Mr. Bolton for his paper. Mr. Bolton was a student who was working his way at the Normal School of Science, and on the occasion of his visits to Rossendale was remarkably industrious in working out the fauna and flora of the Lower Coal measures of the district. He was at present assisting in the preparation of a second edition of Mr. Newbigging's "History of Rossendale." The geological portion of the work was originally written by their former President and Member the late Mr. John Aitken. Mr. Bolton had, with Mr. Newbigging's permission, undertaken to revise and add to it so much as had become known since the time when Mr. Aitken wrote the geological chapters in the earlier edition.

The vote of thanks was duly seconded and passed.

Mr. Wild (who was called upon by the Chairman as a gentleman who had devoted much attention to the coal measure fossils) said he had brought a few specimens for comparison, thinking Mr. Bolton would be present. He regretted that they had not the advantage of his presence. He liked the authors of papers to be present, in order that they might reply to any questions that members might wish to put to them. The specimens exhibited were not well preserved, and the paper would have been more interesting had the author given them—as he expected he would have done—a description of the different kinds of fish remains found over the different coal seams in the Rossendale district. He wished to find out the exact locality of the beds in which these remains were found, and to compare them with the remains discovered in his own district. The Upper Foot coal was very prolific in fish remains, of which some fine specimens were found in the Hapton Valley, near Burnley, by his friend the late Mr. Joseph Whittaker. These ultimately came into possession of the late Sir James

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Kay-Shuttleworth. He thought it was highly desirable that good sections should be made, on a tolerably large scale, and coloured, showing the position in which these different remains were found. He fully endorsed the vote of thanks to Mr. Bolton, and would have been glad if they could have had him present with them.

In answer to a question by Mr. Stirrup,

Mr. WILD said it was frequently the case that separate nodules contained well preserved fish and other remains, including *goniatites* and *orthoceratites*, with fish bones and spines, of many species. The Upper Foot coal or "Bullion Coal" altogether was a very interesting seam, and there were many seams, he believed, in Lancashire of equal interest, if they were properly examined and special sections taken.

Mr. DICKINSON said that some of the goniatites found were quite as large as a person's hand.

Mr. STIRRUP said the *Goniatites Listeri*, which occurred in some seams, was very large. There were one or two places in the Rossendale Valley where the fossils were found of unusual size. He quite coincided in Mr. Wild's wish that these fish beds could be worked out and correlated over the whole of Lancashire.

Mr. WILD exhibited a section, and gave the meeting some further details with regard to the fossil remains to which he had referred, and of which some specimens were handed round for examination.

Mr. DE RANCE suggested that Mr. Wild should be requested by the Society to prepare a more detailed account of the fish and other remains of which he had given the meeting such valuable information. Mr. Wild had evidently paid great attention to the subject, and possessed an amount of knowledge which must be of interest and value both to geologists and palæontologists.

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Mr. Dickinson said he had much pleasure in seconding the proposal of Mr. De Rance. He knew no one so well qualified as Mr. Wild to give a history of the fossil fishes and shells of the Lancashire coal field. He had a great amount of knowledge himself, and there were many good friends who would no doubt help him. Mr. Pickup, who recently sank a shaft 60 yards below the Mountain Mine at Rishton, near Blackburn, found seams which contained some beautiful fossil shells, and the finding of these particular shells enabled Mr. Pickup to identify the strata at the end of his tunnel in driving through a large fault which, he had no doubt, saved him some hundreds of pounds. He was sure Mr. Pickup would be glad to give Mr. Wild particulars with regard to those seams, and with his own information, and what he might obtain from others, he (Mr. Wild) might prepare for the Society a most valuable paper.

Mr. Stirrup said he should be very glad to support that recommendation to Mr. Wild. He had been endeavouring, as some members well knew, for some time past to induce some of those who were connected with collieries to really try and work out, bed by bed, both the flora and fauna of the coal measures of this district. Such work would be of great value not only to the palæontologist, but also, as Mr. Dickinson had pointed out, from a practical point of view. In this way they might be able in time to correlate the beds of the different parts of the Lancashire coal field. Then they might be able to carry on the work to a very much wider area than Lancashire. It was a work that needed doing. Mr. Wild, he believed, was an exceptional authority; he had large collections of fossils illustrating both the flora and the fauna, and if he would make a start he thought they might be able to get some help from other parts of the coal field.

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The CHAIRMAN said he had very much pleasure in supporting the proposition which had been made. There was no doubt that, at times, a knowledge of the mines and of the fossil remains in them would be of great assistance to the workers of mines, in passing through the different measures, by enabling them to determine their position. He had no doubt if Mr. Wild would begin the work others would follow, and little by little they would, in time, get a complete knowledge of points of interest in regard to the geology of the district. One point was as to whether the fact of there being these large deposits of fish could have had an effect in altering the quality of the coal in different districts. In the cannel seams a large amount of fossil fish was found, and it had often occurred to him whether the oil permeating through the coal could have increased its value.

Mr. DICKINSON said it was well known that the ordinary cannel coal had associated with it some minute shells; and the Wigan 4ft. coal had the same; and it, in a portion of Abram Township, became cannel coal also. Only on the previous day he was shown in a pit specimens of rock in which mineral oil had been found, overlying the Trencherbone coal.

Mr BURROWS: How much oil did they get?

Mr. DICKINSON: Just sufficient to get some samples sent to the office.

Mr. BURROWS: We got a bucketful once out of the rock in that way.

The PRESIDENT: I have seen it flow out of the joints in one of our collieries, but not in any large quantity.

The proposition of Mr. De Rance having been unanimously carried.

Mr. WILD said he should have pleasure in complying with the wish of the meeting, and would prepare a paper as soon as he conveniently could.

This concluded the business of the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XX. SESSION 1888-9.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 10th, 1889, in the Mining School, Wigan.

The President, Alderman JOHN KNOWLES, M.Inst.C.E., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Mr. WILLIAM BECK, Ellerbeck Collieries, near Chorley.

Mr. WILLIAM SETTLE, Darcy Lever, near Bolton.

EXCURSIONS.

Mr. M. STIRRUP, the Honorary Secretary, reminded the members that on the following day the visit to the Barton Section of the Manchester Ship Canal, as announced in the circular, would take place.

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He also took this opportunity of inviting a few of the members to take part in a Geological Excursion to Green's Clough, near Todmorden, on the 18th inst., to meet the Bacup Natural History Society.

CORRESPONDENCE.

The Honorary Secretary read the following letters which had been received:—

PROPOSED LANCASHIRE & CHESHIRE BOULDER COMMITTEE.

Dear Sir,

At a meeting of the Liverpool Geological Society a Committee was appointed to report on the boulders occurring in the glacial deposits of Liverpool and district.

This committee, after full discussion, is of opinion that the investigations would be better carried out if extended over the whole of Lancashire and Cheshire, and by a larger committee, consisting of representatives from all parts of the two counties.

The objects of such enlarged committee would be to examine and record the occurrence, nature, and facts bearing on the mode of transport of erratics in the glacial deposits of Lancashire and Cheshire.

If this suggestion meets with general approval it is proposed to hold a meeting of all interested in the question at some convenient centre, at an early date.

I should be pleased to learn, at your early convenience, if you would be prepared to assist in the work, and also to receive any suggestions you would like to make as to the manner in which, in your opinion, the work would be best carried out.

I am, yours faithfully,

J. Lomas,
Hon. Sec. Liverpool Geological Society
Boulder Committee.

23, Avondale Road,
Liverpool, 8th April, 1889.

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GEOLOGICAL PHOTOGRAPHY.

Sir,

At the last meeting of the British Association, held at Bath, a proposal was made to appoint a committee to collect and register photographs of localities, sections, and features of geological interest in every county of the United Kingdom. Isolated attempts at photographic surveys of certain counties or districts have already been made by several of our local societies, but the need is felt to secure uniformity of action by all the societies interested, and to arrange for the photographs to be available for teaching, or other purposes, when needed. The proposal was referred to the committee of delegates of the corresponding societies, who have issued in their report (see *Nature*, vol. 39, p. 187) a number of suggestions relating to the work of the proposed Committee on Geological Photography. Many leading geologists, not only of our country but also of America, warmly supported the scheme. It was ultimately decided to defer the question of the appointment of a committee until the meeting this year at Newcastle, the delegates in the meantime to interest their societies in the matter, and endeavour to promote a harmonious result.

I desire to ask the aid of those members of your society who have interested themselves in the photography of local geological features—especially of typical and temporary sections—in supplying me with the following information:—

(1) A list of photographs already taken illustrating different localities or sections; and

(2) The names of local societies or persons who may be willing to arrange for a photographic survey for geological purposes in their district.

It is intended that the information kindly afforded me will be placed before the geological section of the British Association at their meeting in September next. If copies of photographs are sent me they will be carefully kept to be exhibited at the meeting. Several geological friends have favoured me with hints and suggestions in regard to the size of the photographs, scales of height and length, and other details, which will all be carefully considered. Photography is now so popular and easy of accomplishment that there should be no

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difficulty in organising a local photographic geological survey, by which means the actual details of important sections, &c., will be preserved.

I am,

Your obedient servant,

OSMUND W. JEFFS.

April 30th, 1889.

MARK STIRRUP, Esq., F.G.S.,
Manchester Geological Society.

Mr. STIRRUP said he should be glad to receive the name of any member who would be willing to co-operate in carrying out either of the above desirable objects.

ROBURITE.

The PRESIDENT said they would discuss together the three papers on Roburite, read at previous meetings, one by Mr. James Hilton "On the Use of Roburite in Coal Mines," one by Mr. H. Bramall "On the Effects of Roburite Fumes," and the third by Mr. William Watts, F.G.S., "On Roburite and other Explosives in Mining."

He should be glad to hear any remarks upon those papers.

Mr. R. B. MAWSON opened the discussion. He said he had had some experience of the use of roburite in mines, as the Wigan Coal and Iron Company had used, he believed, something like 7½ tons of it. He had seen most of the experiments tried by Mr. Hilton, both at Kirkless and the Woodshaw pits. At Kirkless they tried to explode the gas by

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roburite shots in every conceivable manner, but on no occasion could they get roburite to fire an explosive mixture. Some sparks were seen at some of the shots fired at the Woodshaw pit, but they were of a dull-red character, and were not, in his opinion, of an intense heat enough to fire gas, which was proved by the experiments at Kirkless. As far as the fumes of roburite being injurious, he might say in the company's operations they had found it was not so in any single case. They had not had a single case of anyone being ill through the fumes. The question of roburite being injurious in handling was a weak point, but he thought the Roburite Company got over that very well by giving strict instructions on the point, and in practical work, if cartridges of a suitable size were ordered, there was no occasion for the workmen's hands coming into contact with the roburite. It was only a question of finding out what size of cartridge was required. At the collieries he had charge of, they had used roburite through the whole of this year, and the men were very well pleased with it. It was very much less expensive than dynamite; it did its work very well, and they found no case in which a man's health had been injured by its use. As far as economy was concerned, it was very superior to the water cartridges, as it took a less quantity, and there was less expense in drilling the small holes. In the gelatine water cartridges they had to have 2½ inch ones, but in roburite they could have any diameter they liked. They found it was very much less expensive, a less quantity was required to do the work, and, in his opinion, roburite was about three times as strong as powder, and did its work exceedingly well.

Mr. J. L. Hedley asked if the report of the medical gentlemen appointed to consider the complaint in the Park Lane dispute had been issued.

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Mr. C. F. Clark said he was unwilling to take any part in that discussion at the present period, as it was probably pretty well known that at the beginning of the year there was at their colliery a serious dispute—in fact, there was a strike throughout the collieries for three weeks in consequence of the alleged detriment to the men's health from the fumes of roburite. An arrangement was come to with the workmen and their representatives that the thing should be thoroughly inquired into. Two disinterested medical practitioners were appointed, with power to call in the assistance of an analyst, to ascertain whether the fumes were at all detrimental. Almost up to the present time those gentlemen had been engaged in making experiments in all sorts of ways, both in confined spaces, wide work, straight work, in places with an ordinary ventilation, &c., to ascertain what gases were evolved from roburite. He had hoped he should be in possession of their report that week, but he was without any knowledge of it being ready. If he had had it he should have had great pleasure in presenting it to the meeting, as it must be of interest to the whole of the mining community. The workmen at the colliery were going on using roburite just as they had been from the beginning, and they had not heard of any case in which the workmen had been affected by the fumes or by handling roburite. Of course from the first very strict instructions were given to the shot-lighters as to how the thing was to be used, and that they should not allow roburite to come into contact with any portion of their bodies. He believed in one or two cases, from the injudicious handling of the material, the workmen themselves had been affected by it. As to the fumes, he did not think from all the inquiries made, that there was a single case that could be charged to them. He should be glad if the discussion could be adjourned until the report was before them.

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Mr. H. Fletcher thought it would be desirable, before any material that was dangerous was introduced, that the managers, owners, and directors of collieries should have the experiment tried upon themselves in the first instance. He thought that only after they had had personal experience of it could they recommend the explosive to be tried by the men.

Mr. Mawson, in reply to Mr. Fletcher, pointed out that Mr. Hilton, in his paper, stated that he was present at the bulk of the experiments, and purposely put himself on the return side, so that he might be in the fumes.

Mr. Fletcher supposed the danger they had to guard against was that of using roburite with insufficient ventilation, and when the new explosive was brought forward it was said to be a substitute for thorough ventilation.

Mr. C. F. Clark: I do not think the Roburite Company ever stated that it was a substitute for thorough ventilation.

Mr. Fletcher said he only referred to notices in the newspapers and conversations, which gave him ground for that remark. With the exercise of proper precautions roburite might be safe, but it was where there was not good ventilation that the fumes became poisonous.

Mr. Saint said he had been told by people, who had used roburite, that in certain cases the whole of the charge had not exploded, and it seemed to him probable that in such cases some of the stuff might be forced into the air current, and must be inhaled by the workmen. That, however, would not account for the experience of the men named by Mr. Bramall in his paper. He did not think a

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man could suffer from such poisoning, unless he was suffering from the fumes resulting from the explosion. It would be well if some of the managers would give their experience as to whether it would not be desirable to arrange as far as practicable that the drawing and travelling roads should be the intake airways of the working places.

Mr. J. L. HEDLEY said there was a point about roburite, which was of more importance than the question of fumes, and that was the question of flame. There had been recently in the Wigan district an accident from the use of roburite. He was not going to express an opinion upon it, but should like them to form their own conclusion from what he would tell them. A charge of roburite was inserted, but it did not explode, nor did the cap. In accordance with the regulations of the mine the fireman left the shot for a little time, then went back and charged another hole nine inches from the first. That was exploded, and the coal was brought down, with the exception of a small quantity round the first cartridge. The place was again left, and on the fireman returning to it, after a lapse of two or three hours, he commenced to cut the unexploded cap out, the instructions being that when a cap was not exploded they were to take every care to get it out. In doing this the man unfortunately struck his pick against it and it exploded, and being within a short distance of the roburite he was very much blown about the face and chest. He (Mr. Hedley) suggested to Mr. Webster that he should particularly inquire whether the man had received any burning at all, and it was found that the man was not burnt in the slightest degree, although his face was on a line with the cartridge when it exploded, and at the outside a couple of feet from the cartridge. There were no signs of burning on his face, and his hair was not burnt in the slightest degree. He thought they would all draw their conclusion from that as to the safety of roburite

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as compared with gunpowder. Had that been a gunpowder shot, the man must have been very seriously burned considering the small amount of coal there was between the shot and the man. He thought it must be patent to everybody that, taking that particular case, roburite was certainly more flameless than gunpowder, and he thought that was what Mr. Hall said at the last discussion in that room, that although roburite might not be perfectly flameless, still as compared with gunpowder it was comparatively safe. With regard to the fumes he had made considerable inquiries about them, but he had not yet come across a case where a man had been injured by the fumes themselves. Mr. Webster informed him that at the colliery under his charge about 250 shots of roburite were fired every night. They had been using roburite for a considerable time, but only one man had suffered at all, and he, it was found, had been handling the explosive in a raw state. Since he had been warned about it that man had not suffered. Presuming that there was any danger or chance of injury from the fumes, it was a matter that could be very easily got over. Every one knew the difficulty that surrounded the use of gunpowder in the pit, not only from the presence of gas—he did not think anyone would think of firing roburite or gunpowder where there was gas—but in dusty mines. There were a large number of dry dusty mines in this district where gunpowder could not be used without watering the places thoroughly, and it came to the question whether gunpowder should be done away with altogether, or whether roburite was considered sufficiently safe to use in place of gunpowder, in which case it would not be required to water the mines as when gunpowder was used. If there was a risk from using roburite when men were down the pit he asked why not carry out the system which had been in existence at a large number of collieries in this district for a number of

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years now of firing the shots when the men were not in the pit. There could not be the slightest injury to the men in that case, and the shot-lighters need not go back to examine the shots for a short time, and when they did they could go with the wind, and not get into the fumes at all. The difficulty about the fumes could be got over by firing the shots when the men were out of the pit, and allowing only firemen to do the work.

Mr. FLETCHER said that although the man had not been injured in the above named case, yet had the shot been of ordinary gunpowder there would have been no necessity to cut it out. It was the necessity of cutting it out that led to the accident.

Mr. HEDLEY said the gunpowder shot might have gone off just in the same way as the roburite, but that was not his point, for the shot was being cut when it went off, and the man was not burnt. The case appeared in a good many papers, and he thought a wrong construction might have been put upon it, namely, that the man was burnt. That was not the case, and it was, he thought, an argument in favour of the safety of roburite from the flameless point of view. He had never met with a case of a fireman being injured from the use of roburite, and he attributed it to the fact that they knew how to use it, and probably they did not stop in the working place for any length of time, presuming the fumes were there. The circulation of the air ought to be kept up, and after a shot is fired it was not necessary for the man to go in the working places immediately. He could wait for a short interval, and then go in and examine. He thought they must conclude from the fact that the firemen and shot-lighters were not injured from the fumes that there was not much risk or danger to their lives from that cause, and he did not think that

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at all affected what he had said about firing the shots when the men were out of the pit. In any event, if the worst came to the worst, they had to choose between having two or three men running the risk of being injured, and risking the lives of 200 or 300 men.

Mr. W. Bryham, Jun.: I should like to ask Mr. Clark if the shots were fired in the day time when the men were down the pit?

Mr. Clark: Yes, the shots were all fired in the day time.

Mr. Bryham said he preferred to fire the shots when the men were out of the mine. They used to fire something like 300 shots in the day—what the colliers called "pop shots"—but when they discontinued the practice they could do the same amount of work with 150 shots. They had not had any complaints from their officials or colliers as to the fumes. He had every confidence, as far as they had gone, in the use of roburite, and he should continue to use it until he had some complaint.

Mr. Mawson, in reply to Mr. Fletcher, said they tried roburite in the most dangerous explosive mixture they could get, and in his opinion one of the finest arguments in favour of the use of roburite was that Mr. Bramall was still using it.

Mr. Cockson suggested that the discussion be adjourned to an early meeting to be held in Wigan. He took it Wigan was the centre where they got the largest attendance of members interested in mining, and it was advisable to adjourn the discussion until the medical report was issued. If Mr. Bramall had been present he would have asked him if the symptoms of poisoning had not occurred

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only where the men had had a direct handling of roburite. As to the mixing of roburite with the atmosphere, the only case in which that could happen was where the detonator missed fire and the charge was not exploded at all. Everything would be done to get the detonator and roburite from the coal, so as to avoid sending stuff away with a dangerous explosive in it, but he took it the shot would be got out bodily, that the thick casing of the cartridge would not be cut, and that therefore it would be impossible for roburite to get into the air. The other case, where it was suggested roburite might mix with the air, was where two or three cartridges were put in one shot hole, and only one cartridge exploded. In a case of that sort he found that the cartridge left unexploded was so compressed as to be harder than coal itself, and it was impossible for such roburite to mix with the air. He would suggest, as that was a most important question to colliery people, that the meeting should be held as soon as possible, and not deferred until next winter, because Mr. Bramall's paper had made people in this district who thought of using it afraid, and they had continued to use powder in preference to what he considered an infinitely superior explosive. It was for the general good of the mining community that the discussion be brought to a head as soon as they had sufficient information.

Mr. FLETCHER: If the masters will not put their persons in jeopardy they should put their purses by guaranteeing the men against all accidents which arise. That, I think, is a better solution for every difficulty that may occur between masters and men, on questions of safety, than that of outside insurance with societies that have no influence on the management.

Mr. WINSTANLEY said he knew as a fact that Mr. Bramall

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did not write his paper in an antagonistic spirit towards roburite, because he spoke highly of it. If the discussion were adjourned Mr. Bramall would have an opportunity of attending a future meeting, and might more fully explain his views.

Mr. GRUNDY said the whole tone of Mr. Bramall's paper was to put people on their guard when using the explosive. They might have an explosion when the combustion was not complete, and the tone of Mr. Bramall's paper was to treat the substance as if the fumes from it were not pure. He was surprised that the mine owners and managers sat still while Mr. Fletcher insinuated that no one else had good ventilation except himself.

Mr. WINSTANLEY moved that the discussion be adjourned.

The CHAIRMAN said Mr. Hedley had mentioned a case of the explosion of a shot which missed fire, and that the person was not burnt, which showed there was not sufficient flame to injure him. That was an advantage from the use of roburite. With respect to the remarks of Mr. Fletcher, he must say very strongly there was no intention on the part of colliery managers to use an explosive or do anything which would interfere with the ventilation. Mr. Bramall had gone to America for a holiday, but when he came back he would no doubt be glad to attend a meeting and discuss the subject. The intention of Mr. Bramall was not to find fault with roburite, but to caution people so as to avoid anything arising from the fumes. He (the President) tried burning roburite on the hearth, and the fumes arising had certainly a slight effect upon him. It was possible to fire a shot and not explode the whole of the gunpowder, and was it not possible in roburite that some part might be blown out and burn, and that the burning might be more

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deleterious than the explosion itself? Those were points which ought to be considered, and great caution ought to be exercised in the use of explosives. The discussion should be adjourned until Mr. Clark got the report from the medical gentlemen conducting the experiments, and if he could give any facility or information at their works he should be glad to do so.

The motion was seconded and carried, and Mr. Clark promised to communicate with the Secretary as soon as he was in possession of the report.

GOAF STOWING.

The PRESIDENT next invited discussion on the paper read by Mr. H. Fletcher at the last meeting of the Society, entitled "The effects of goaf stowing on sudden issues of gas and on ventilation."

Mr. BURROWS said Mr. Fletcher's paper seemed to introduce a comparison between pillar and stall and long wall, and we ought to confine the discussion as to whether his long wall system is any better and cheaper than the present system of packing. With regard to lighting, there was no doubt that candles were preferable to lamps; but there was the risk to be taken into consideration, and he would suggest to Mr. Fletcher to use the electric light. He intended to make the experiment. At one of their collieries the only place for many months where gas was reported to exist was where the packing was solid. He did not infer that the gas issued forth because of the stowing, but it so happened to appear there, and stopped the place for several days.

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Mr. FLETCHER said it was stated in the paper that the solid packing had been attended by a diminution in the cost of 3d. a ton in wages. In speaking of ventilation, he said that lamps were sometimes relied on instead of ventilation. He had heard of lamps being so used as cheaper than ventilation.

Mr. BURROWS: Are you speaking of this year or ten or fifteen years ago?

Mr. FLETCHER: I am speaking of this very day.

The PRESIDENT thought it was unfair of Mr. Fletcher to make those assertions.

Mr. BRYHAM said he could vouch that such was not the case in this district, and he must protest against the insinuation that the men were allowed to work with lamps when it was unsafe.

Mr. BURROWS: I think Mr. Fletcher ought to communicate with Mr. Dickinson.

Mr. TOPPING: I think he ought to retract. It is hardly fair.

Mr. MAWSON thought it was not fair for Mr. Fletcher to condemn other colliery managers because they did not act upon his system.

Mr. FLETCHER, on being appealed to to mention names, said he would not publish the names of the collieries, and he did not think anyone would be hurt by the anonymous assertion.

Mr. BURROWS again suggested that Mr. Fletcher should use the electric light.

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Mr. FLETCHER said he had tried the portable Swan-Edison-Pitkin lamps for a few months, without success, and believed semi-portable lamps, connected by wires in circuit, would be impracticable in the working places, and there was no necessity if they kept up a good ventilation, abandoned narrow-work, and filled up the goaf.

The subject then dropped, and a vote of thanks having been accorded the President, the meeting concluded.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XX. SESSION 1888-9.

The ORDINARY MEETING of the Members was held on Tuesday, June 4th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. Alderman JOHN KNOWLES, M.Inst.C.E., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. REUBEN TAYLOR, Pendlebury Colliery, near Manchester.

Mr. JOHN W. FOSTER, Silksworth Colliery, Sunderland.

The following are the recent additions to the Library:—

Chesterfield and Derbyshire Institute of Engineers: Transactions, Parts 3-4, Vol. XVII. *From the Institute.*

Dublin, Royal Dublin Society: Scientific Proceedings, Parts 3-6, Vol. VI., N.S.; Scientific Transactions, Parts 2-5, Vol. IV., Series 2.—*From the Society.*

Edinburgh Royal Physical Society: Proceedings, Session 1887-88.—*From the Society.*

Essex Field Club: Journal, Nos. 11-12, Vol. II., 1888.—*From the Club.*

Hampshire Field Club: Papers and Proceedings, Nos. 1-2.—*From the Club.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 4-5, Vol. V.—*From the Society.*

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Leeds Geological Association: Transactions, Part 4, 1888.—*From the Association.*

Leicester Literary and Philosophical Society: Transactions, Part XI., 1889.—*From the Society.*

Liverpool Geologists' Association: Transactions, Vol. VIII., Session 1887-88.—*From the Association.*

London Geological Society: Quarterly Journal, No. 178, Vol. XLV., Part 2.—*From the Society.*

——— Geologists' Association: Proceedings, No. 9, Vol. X., Nos. 1-3, Vol. XI., Contents and Index Vol. X.—*From the Association.*

——— Geological Magazine: April, May, June, and July, 1889.—*Purchased.*

——— Institution of Mechanical Engineers: Proceedings, No. 1, 1889,—*From the Institution.*

——— Palæontographical Society: Vol. XLII., 1888.—*Purchased.*

——— British Association Report: Bath Meeting, 1888.—*Presented by the Council.*

——— Official Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1889.—*Purchased.*

——— Royal Society: Proceedings, Parts 276-279, Vol. XLV., Part 280, Vol. XLVI.—*From the Society.*

Manchester Association of Engineers: Thirty-third Annual Report, 1888, Four Pamphlets.—*From the Association.*

——— Field Naturalists' and Archæologists' Society: Report and Proceedings, 1888.—*From the Society.*

——— Microscopical Society: Annual Report, 1888.—*From the Society.*

Midland Institute of Engineers: Transactions, Parts 101-102, Vol. XI.—*From the Council.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Parts 1-2, Vol. XXXVIII.—*From the Institute.*

Scotland, Mining Institute of Scotland: Transactions, Part 9, Vol. X., Parts 1-2, Vol. XI.—*From the Council.*

South Wales Institute of Engineers: Proceedings, No. 3, Vol. XVI., and Rules.—*From the Institute.*

Yorkshire Geological and Polytechnic Society: Proceedings, Vol. X., History of the Society, 1837-1887.—*From the Society.*

Congrès Géologique International, Fourth Session, London, 1888, Explication des Excursions.—*From M. Stirrup.*

North Shields, Potts' Mining Register and Directory for 1889.—*Presented by Publisher.*

Organization of Fossil Plants of the Coal Measures: Part 15, by Prof. W. C. Williamson.—*Presented by Author.*

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Changes in the Earth's Crust, by Dr. Ricketts: Pamphlet.—*From the Author.*

The following presented by W. Whitaker, F.G.S.:—

List of Works on the Geology, Mineralogy, and Palæontology of Shropshire: Pamphlet, by W. Whitaker.

Report on the Tertiary Lignite Formation near 49th Parallel: Pamphlet, by G. W. Dawson.

Annales des Sciences Géologiques: Vol. III., 1881. By M. Vasseur.

Nitrate and Guano Deposits of Atacama.

Introductory Lectures at Museum of Practical Geology. By Edw. Forbes, John Percy, A. C. Ramsay, W. W. Smith. Four Pamphlets.

Introductory Lecture, University College, London. By A. C. Ramsay. Pamphlet.

Cambridge University, 23rd Annual Report of Museum and Lecture Rooms Syndicate.

Liverpool Free Library and Museum, 36th Annual Report, 1888.

Canada, Canadian Institute, Toronto: Proceedings, No. 2, Vol. VI., Annual Report, 1887-88. *From the Institute.*

——— Ottawa, The Canadian Mining Review: March to June, 1889, Nos. 3-6, Vol. VIII. *From the Editor.*

U.S.A., Harvard College: Bulletin of the Museum of Comparative Zoology, Nos 4-5, Vol. XVI., No. 3, Vol. XVII.—*From Alexander Agassiz.*

——— New York, American Museum of Natural History: Bulletin No. 2, Vol. II, March, 1889, Annual Report of the Trustees, 1888-9.—*From the Trustees.*

——— Philadelphia, Academy of Natural Sciences: Proceedings, Part 3, 1888. *From the Academy.*

——— Philadelphia, Journal of Franklin Institute. Nos. 759-762, Vol. CXXVII., No. 763, Vol. CXXVIII. *From the Institute.*

——— Sacramento, 8th Annual Report of State Mineralogist, California, 1888.

——— St. Paul, Geological and Natural History Survey of Minnesota: 16th Annual Report, for year 1887.—*From W. H. Winchell.*

——— Scranton, Pennsylvania, the Colliery Engineer, April to June, 1889, Nos. 9-11, Vol. IX.—*From the Editor.*

——— Washington, United States Geological Survey: Bulletin, Nos. 40-47, 1887. Mineral Resources of United States, 1887.—*From the Director of the Survey.*

India, Calcutta, Records of the Geological Survey of India: Parts 1-2, Vol. XXII.—*From the Governor General in Council.*

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Sydney, Royal Society of New South Wales: Journal and Proceedings, Part 2, Vol. XXII., 1888. *From the Society.*

List of Members of Geological Society of Australasia.

——— Geological Survey of New South Wales: Memoir, Palæontology, No. 2, Tertiary Flora of Australia. Records of Geological Survey of New South Wales: Part 1, Vol. I., 1889. Descriptive Catalogue of Exhibit of Metals, Minerals, &c., at Melbourne International Exhibition, 1888.—*From the Minister for Mines.*

Victoria, Gold Fields of: Reports of Mining Registrars, Quarter ending December, 1888.—*From the Government.*

Berlin, Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 3, Band XL., 1888.—*From the Society.*

Brussels, Sur la découverte à Ixelles, d'un ossuaire de Mammifères: Pamphlet.—*From the Author, M. Mourlon.*

Buenos Ayres, Censo Municipal, 1887.—*From the Government.*

Christiania, Royal University of Norway: Reusch Bömmelöen, with English Summary, 1888.—*From the University.*

Dresden, Sitzungsberichte der Naturwissenschaftlichen Gesselschaft Isis in Dresden: January to June, 1888; July to December, 1888.—*From the Society.*

Halle, a/S, Ksl. Leop.-Carol Deutschen Akademie der Naturforscher: Leopoldina, Heft 24, Elephas antiquus by Dr. Pohlig.—*From the Academy.*

Igló, Jahrbuch des Ungarischen Karpathen-Vereins: 16, 1889.—*From the Society.*

Kieff, Russia, La Société des Naturalistes: Proceedings, Vol. X., No. 31, 1889.—*From the Society.*

Lausanne, Bulletin de la Société Vaudoise des Sciences Naturelles: No. 99, Vol. XXIV.—*From the Society.*

Napoli, Rendiconto dell'Accademia delle Scienze Fisiche e Matematiche: Fasc 6-10, 1888.—*From the Academy.*

Paris, Revue de le Legislation des Mines: January-February, 1889, March-April, 1889.—*Purchased.*

——— Sur un Nouveau Poisson Fossile: Pamphlet, by Chas. Brongniart. Les Blattes de l'Epoque Houillère: Pamphlet by Chas. Brongniart.—*Presented by the Author, M. Charles Brongniart.*

——— Annuaire Géologique Universel: Vol. IV., 1888.—*From Dr. Dagincourt.*

Pisa, Atti della Società Toscana di Scienze Naturali: Processi Verbali, Vol. VI., January to May, 1889.—*From the Society.*

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Roma, Atti della Reale Accademia dei Lincei: Memorie, Vols. III. and IV., Series 4; Rendiconti, Fasc 11-12, Vol. IV., 1888; 1-6, Vol. V., 1889.—*From the Academy.*

San José, Rep. de Costa Rica: Argument and Reply on the question of the Treaty of Limits between Costa Rica and Nicaragua, 1887, by P. P. Zeleden.

St. Petersburg, Academie Impériale des Sciences: Memoires, Nos. 12-16, Tome XXXVI.—*From the Academy.*

ADDITIONAL NOTES ON RICHMOND COAL FIELD, VIRGINIA, IN REPLY TO CRITICISMS.

By Mr. William Clifford, M.E.

Having had my attention called by Mr. Stirrup to an article in the *Geological Magazine*, for March of this year, reviewing the paper on the Richmond Coal Field, Virginia, which I read before this Society, December, 1887, I desire to lay before the members the following remarks thereon:—

The review in question is from the pen of Mr. F. H. Newell, and refers in part to matters of fact, and in part to speculative geology, especially to the views of Sir C. Lyell and others, so far as they bear upon the subjects touched upon in the paper.

As to matters of fact, the reviewer seems lacking in information on the general subject, while in speculation he seems bold in the extreme, denying the conclusions of authors who reasoned from premises furnished by rocks laid bare before their eyes, or who described simply what they saw.

Accidents and commercial failure having closed the avenues of information formerly afforded by the working of the mines about Midlothian, the geology of that district (where the peculiar characteristics of the coal field were most marked) has become a sealed book, whose contents are known to us principally through the writings of actual observers who have in former years examined the mines and

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the adjacent country from time to time; and also through the more recent surveys and descriptions of the mines themselves as set forth in several papers read before the American Institute of Mining Engineers by the late Mr. Oswald J. Heinrich.

We cannot lightly set aside the statements and deductions of Sir C. Lyell, Mr. Taylor, and Mr. S. H. Daddow, as to the manner of the occurrence of these coal measures, and as to the shape of the floor upon which they and the Triassic rocks beneath them were each in turn deposited. The writers referred to are all competent men, possessing the special advantage afforded by inspection of mines in vigorous work in every part of the coalfield. Their statements are authoritative, and their deductions the outcome of personal investigation, and not bare assumptions, as put by Mr. Newell.

We will proceed to examine Mr. Newell's criticisms in the order in which they occur.

On page 138, No. 3, March, 1889, of the Magazine referred to above, the reviewer says:—

"The statement of first importance on which many deduc-
"tions rest is that the strata thin out at the outcrop, or to
"give the exact words, 'the rocks thin out toward the sides
"of the basin, as though, during their deposition, the rock
"material had slid somewhat down the steep sides on which
"it was thrown down.'"

"A careful exploration made this year failed to give con-
"clusive evidence of such general thinning," &c.—Probably this year means 1888.

The exploration referred to cannot have extended to the Greenhole basin at Midlothian, where thinning of the measures is distinctly to be seen both above and below the coal, and in one place in the coal itself. On the eastern outcrop, in what is known as Mark's New Slope

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(Fig. 1, Plate I. and Plate III., *Trans. Man. Geol. Soc. Part 13, Vol. XIX.*), the inclination of the coal is greater at the outcrop than it is further to the dip. The ground underlying the seam has been cut away to diminish the gradient of the incline over which the coal was formerly hauled to the surface. Here thinning of the rocks *below* the coal is seen. A little further to the north in the same basin, and on the same side of it, in one of the "Old Sowell" inclines which has fallen up to the surface, the same phenomena can be seen in the shales *overlying* the coal. To the west of the Greenhole basin, in a trial hole,—where the leader of the coal from the Greenhole basin comes near the surface thickening to the dip (east), is very marked, and extends to the black sand and marls which form the base of the drift at this point. Thinning could also be seen in the measure overlying the coal in the old working, fallen in, near Finney's on the western outcrop in 1884, and in dozens of places underground on the dip side of "troubles" in the several collieries.

On page 139 of the same journal Mr. Newell says:—"There is far too much stress put upon the assumption made "by Lyell, and since then unquestioned, that the present "basins were basins at *the beginning of the Triassic*, and that "the irregularities are due to deposition or uneven surfaces, "rather than to subsequent crushing. The evidence, on the "contrary, points to the fact that the coal series was "deposited in a horizontal position. Not enough allowance "has been made for the effect of subsequent crushing and "erosion of soft rocks."

To get a fair grasp of Sir C. Lyell's views, the chapter referring to this coal field in Vol. I., of his Second Visit to the United States should be read. Speaking of the *Calamities* and *Equisetites* he says:—"They are very commonly met with in a vertical position, more or less compressed

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perpendicularly." He saw them in places many miles apart under the same conditions, and concluded that they must have grown where they are now buried in mud and sand, and that this "implies a gradual accumulation of the coal "measures, during a slow and repeated subsidence of the "whole region." The angle of inclination of the measures where these huge plants now stand, is in many cases as much as 60 degrees.

That the Triassic was deposited upon a more uneven floor than the one which in its turn formed the area of deposit for the coal measures, is manifest at every point of exposure. It fills up as it were, the hollows in what Sir C. Lyell terms the "fundamental granite." Its thickness is greatest in the southern portion of the field, but very irregular everywhere. In the bore hole near the Grove shaft, it is over 500 feet, while less than a mile away it varies within a small area, from a few inches or nothing to 100 feet. At Midlothian, granite troubles were often met with when the pits were at work, presenting rugged sides. Sometimes a nearly perpendicular face was met with, standing out of, and rising above the coal seam—the end of the coal resting smooth and uncrushed directly against the granite.

In the present workings at Clover Hill, which are deep, the writer did not see any granite in cuttings through "troubles." Here the "troubles" are of the form described in the paper—having a rounded-off appearance—the Triassic sheath has softened the asperities of outline possessed by the granite core.

It was told to the writer that the troubles at the Raccoon pit were clean dislocations, and generally down-throws to the S.W., but examination showed that there were no "clean slips;" that in heading through a "trouble" the usual film of coal was followed along the level line until it came to a workable thickness again, showing that to the

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irregularities of the floor, and not to disturbance, must be referred the contortions of the seam. On the other hand in depressions in the floor the coal was of extra thickness, sometimes assuming the form of large pots.

Now as to Mr. Newell's evidence:—"It is well known "that one of the principal coal beds, dipping at an angle "averaging 30 degrees, has been worked along the strike "for, say a mile, and has been explored on the dip for 1,500 "feet, equivalent to a vertical depth of 750 feet. Through- "out this breadth of 1,500 feet it maintains approximately "a uniform thickness, &c."

From the general tenor of Mr. Newell's remarks, and from his letters to me, it would appear that they had reference mainly to the north-western outcrop. In 1884 only limited examinations could be made in this part of the field,—not a single pit being at work there at that time. Mining enterprise was dead, but has since been galvanized into life by the influx of Boston capital.

Persistent enquiry of those persons most competent to give information, and inspection of such plans and sections as were accessible, lead me to no such conclusion that in any part of the western outcrop was there any working or series of workings aggregating one mile wide and 750 feet in vertical depth, unless we accept that the term "worked" to include a chain of primitive burrowings along a very narrow fringe of outcrop, and "explored" to mean perhaps the solitary slope that had been carried 1,500 feet to the dip.

There are in the Richmond coal field two parts having distinct characteristics (shown in Plates II., III., and IV. of the paper, *Trans. Man. Geol. Soc., Part 13, Vol. XIX.*) The coal in the Carbon Hill district is split up into a number of small beds, with measures differing as widely from those of Midlothian and Clover Hill as do the strata

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of Cannock Chase, in England, from those of the adjacent Black Country.

In the northern end of the Richmond coal field we have evidences of strong heat, and on the western side trap as a conformable mass *over all the ground hitherto proved.* The focus of volcanic energy appears to have been somewhere about the James river, and to have extended in a north-westerly direction towards Dover. Just south of the James or the eastern outcrop everything is topsy-turvy,—this is where hæmatite was formerly worked. Two miles further south, on the western side of the Black Heath basin, there are surface indications of heat and disturbance, probably the spent force which produced calcination at Jewitt's (Plate IV., Fig. 2, *Trans. Man. Geol. Soc, Part 1?, Vol. XIX.*) close by.

At Midlothian there were no appearances of volcanic action discovered in the coal workings. The seams are few or single, and very thick. In the shallower workings of former days the coal was found resting partly on the projections from the granite floor, and partly on Triassic rocks deposited in the hollows of the original floor. At Clover Hill, 19 miles further south, the absence of heat, and the same ponderous coal seams, "steep pinches" and irregularity of stratification prevail.

A trap dyke comes to the surface at Buck Hill, three miles S.W. of Midlothian. Whether it is connected with Jewitt's coke pit, no exploration has yet been made to determine. The nearest underground workings are those of the Grove shaft (one-and-a-half miles away), where no crushing or heating is to be seen.

On pages 139-140, Mr. Newell says: "The identification "of any coal seam for a distance of even one or two miles, "is a matter of great uncertainty, owing to the number of "the seams, the changes in thickness both of the coal and

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"accompanying shales, the bending and crushing to which "all have been subjected, and the rapid decomposition of "the whole series." It is difficult to know what is meant by the rapid decomposition of the whole series. No superficial examination of the strata can be made with the smallest success. The marls and clays at the base of the drift have hermetically sealed the outcrop, and arrested decomposition there. It is only in the few places where streams have washed away these superficial accumulations, that any idea of the form of the underlying rocks can be obtained without digging.—See description of prospecting at Deep Run, on paper.

In the remarks quoted, one would like to know whether Mr. Newell refers to those regular measures with parallel laminæ, north of the James river, which he has previously described? *The very regularity, persistency, and stratigraphical position of these coal beds should render their identity quite easy.* But if he speaks of what may be termed the non-plutonic parts of the field (Midlothian, &c.), then Mr. Newell's acquaintance with conditions only found within a circumscribed area, has misled him in drawing general conclusions. There are broad physical differences—fracture, lamination, &c.—in the coals themselves as obtained from the several seams, differences common to those seams when occurring, *not two but twenty miles apart.* These differences and the associated shales make identification easy. The coal obtained from detached basins at three points extending over 13 miles of eastern outcrop, was grooved and furrowed in a great diversity of directions, in the same way as coal obtained from the Silkstone seam where it rears, as against the Brimington anticlinal in Derbyshire, and where the colliers called these markings "shivers."

We now come to the final and perhaps, from an economic

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point of view, the most important of Mr. Newell's objections. The make of water in coke pits. The only coke pit at work in the whole field in 1884 *had* fissured measures above and below the trap, and made a large quantity of water in the shaft and the workings,—which were limited in their extent, all straight-work, and no break in the roof had occurred anywhere. On the cause of the abandonment of coke pits worked in the past, the re-opening of one or more during the last year or two may throw some light, but my information was definite and reliable. The make of water was carefully taken by the leading mining engineer of the day. The average quantity was 17 tons for every ton of coke raised—a very large quantity to be dealt with by the means at command.

The subjoined appendix embraces all the chief published opinions of actual explorers of this coal field (which have come in the writer's way) relating to the particular subjects under discussion, and it is hoped that they will serve to further make it clear that the criticisms under notice are against facts and against the consensus of opinion of competent authorities.

Sir C. Lyell (1844 and 1845.)

"Second Visit to the United States."

Page 280.—"These eastern coal beds, the largest of which rests "upon the fundamental granite, while the uppermost are not covered "by any overlying fossiliferous formations.

Page 281.—"The beds lie in a trough (see Section Fig. 4, p. 283), "the lowest of them usually highly inclined when they crop out "along the margin of the basin, while the strata higher in the series "occupying the central part of the area, and which are devoid of "organic remains and coal, are nearly horizontal.

Page 282-283.—"The annexed ideal section will show the manner in "which I suppose the coal field to be placed in a hollow in the granite "rocks, the whole country having suffered by great denudation, and "the surface having been planed off almost uniformly, and at the

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'same time overspread by a deep covering of gravel, and red and "yellow clay, &c.

Page 284.—"This great seam is sometimes parted from the granite "by an inch or two of shale, which seems to have constituted the soil "on which the coal plants grew, at some points the granite floor "touches the coal, the contact may be occasioned by subsequent "disturbances, for the rocks are fractured and shifted in many "places."—Refers to Black Heath pit.

Taylor (about 1850).

"Coal Statistic."

Chapter in Virginia, Macfarlane, p. 509-516.

"After this coal has been excavated and its base laid bare, the floor "of the mine exhibits the original undulating surface of the granite, and "in some few instances, the eminences which protrude from this ancient "surface, rise entirely through the lower carboniferous beds, as, on "a larger scale, an island rises above the water of the ocean. Thus, "the floor of the deep galleries present an irregular and undulating "surface, to the inconvenience of the miners, and occasioning ob-"stacles to the formation of subterranean railroads. It is not always "that the coal rests immediately on the granite, occasionally there is "a foot or two of black carboniferous shale, or a seam of from one to "two inches of dark porphyritic rock. Often many square yards of "granite are laid bare, where its surface appears smooth and worn by "previous attrition before the deposition of the vegetable matter had "commenced. There exists no parallelism between the upper and "lower surfaces of the main coal seam, neither does the roof present "the usual continuity of planes as is seen in ordinary stratified "deposits. In these lower thick seams, the roof is irregular, rising "and falling, swelling and expanding, without at the same time "conforming to the undulations of the granite base: The parallelism "of laminæ, or plates of stratification within the body of the coal "itself, however, is not interrupted, but they continue of uniform "thickness parallel to each other, and with the prevailing dip of the "coal. The prevailing circumstances which are developed in this "remarkable mass of coal, are such as would be expected to attend "the deposition of vegetable matter, or any substance in fact, not "altogether in a state of fluidity, yet capable of entering into and "filling up the innumerable inequalities and minor cavities in the

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"original granite bed, and, at the same time maintaining in the "plane of its own superior surface, a certain general parallelism, or "level. They thus furnish a ready explanation as to the otherwise "singular irregularities in thickness of the great lower coal seam, so "different from the usual characteristics.

"Daddow."
"COAL, IRON, AND OIL."
Pottsville, 1866.*

Page 396.—"*Richmond Coal Field.*"—"The basin is irregular, and "is surrounded by fine grained granite, resembling syenite, which "produces an excellent building material, almost equal to marble in "appearance. The interior of the basin presents peaks of granite of "various textures, with occasional dykes of trap and porphyries. "The field consists of a series of deep basins, the whole resembling "the vast crater of some expired volcano, studded with sharp peaks "and surrounded by rugged and irregular sides. The inequalities "of the basin are in a measure modified by sedimentary deposits which "preceded the coal, but these deposits only filled the deeper hollows, "leaving the coal in many cases to be stratified on a granite base. "*It seems evident that no subsequent crust movements of importance have "taken place in these eastern and late coal formations. The deposits are "in the deeper basins or synclinals, limited on the declining sides, and "very thin on the anticlinals, thus proving positively that the basins "existed much in their present condition when these deposits took place.*"

A vote of thanks to Mr. Clifford was unanimously passed.

ON CARBONIC ACID GAS, OR BLACK-DAMP, AS COMMONLY FOUND IN MINES.

BY MR. JOSEPH DICKINSON, F.G.S., &c.

At the monthly meeting of this Society in November last, mention was made of carbonic acid gas having recently, by a party of scientific gentlemen, been found issuing audibly into the workings of the Foxdale mine, in the Isle of Man.

*Mr. Daddow built and managed just before the war, the West Ham furnace on the James river between Richmond and the coal field, and was therefore intimately acquainted with the district.

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I stated at once that I had heard of a similar occurrence in a mine in Germany, but which I attributed entirely to the effects of some large shots of dynamite which were being fired, and not at all to ordinary carbonic acid gas; and that in all my experience I had never met with such gas issuing audibly, but only firedamp. It is a well-known fact that in mines the issue of carbonic acid is usually if not invariably silent; and as the effects of a strong mixture are so sudden and so deadly, and as fatal accidents continue to occur chiefly from persons venturing too far, or remaining where a light will not burn, and from incautiously descending pits or wells, putting the head into old workings without first testing whether light will burn, therefore the waiting for any additional test such as sound might throw a miner off his guard until too late, and I trust that I may be excused for recurring to the circumstance.

It occurred to me afterwards that notwithstanding the innumerable number of times such gas has been noticed by me lying silently and extinguishing lights either near the floor of workings, or in shafts, or pouring out of old workings, it might be possible for an issue to be audible if the gas were under a certain pressure; I have therefore taken an opportunity of bringing the subject under the notice of some of my experienced mining friends, and I find that their experience agrees with my own, namely, that all the issues met with by them were silent; and as the name of Mr. Kitto, the principal agent of the mine, was mentioned as being present when the issue was noticed by the scientific party, we decided to write to him on the subject, and his reply to my colleague, Dr. C. Le Neve Foster, dated 28th February, 1889, is as follows:—

"I do not think I ever heard the carbonic acid gas blow-
"ing or rather singing myself, and I have inquired from
"the other agents, and they say not, but we have many

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"times felt it against the back of the hands very similar to "cold air being blown through the stem of a tobacco pipe. "The next time I find any of those little 'pipes' I will "carefully listen. The fact is we always keep our mouths "as far as possible from it."

The issue of this gas in this mine had, I find, been previously noticed by Dr. Foster, who had it tested, and it proved to be carbonic acid, or what the chemist called by the new name carbonic anhydride.

It is important, therefore, to have this further assurance that, when the presence of the gas is indicated by the flame of a candle or a lamp becoming dimmed or extinguished, there should not be any waiting to hear sound, as the inhalement may very suddenly prove fatal to life.

The percentage of carbonic acid which proves fatal to life has been variously stated by writers, but I do not know that it has ever been more accurately given than on the high authority of Dr. R. Angus Smith, the chief inspector of alkali works, who experimented practically on the quantities in a special compartment which he had constructed for such purposes.

The quantities set forth by him in evidence, and given in my annual report for 1865, are to the effect that: The injurious proportion is so small that only a quarter of one per cent. of carbonic acid in air is sufficient to make a workshop be considered close; and in any place where there is two per cent. or less, candles are extinguished; and that from his experiments he believed few people could bear four per cent. of carbonic acid in air long, and that it would be rapidly fatal to some.

The thanks of the meeting having been voted to Mr. Dickinson for his paper,

Professor Boyd Dawkins (who was in the chair in the temporary absence of the President) said: I have listened

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with very great interest to what Mr. Dickinson has said, and to some extent I think I may be said to be responsible for his communication. I most frankly say that Mr. Dickinson has very satisfactorily disposed of what certainly, when I was at the bottom of that deep mine in company with Mr. Kitto, seemed to me to be a hissing noise. I fully and frankly say that I think I must have been mistaken. I would not think for one moment of paying any particular attention to that one isolated and incidental observation of my own, as compared with Mr. Kitto's observations in this mine, Mr. Dickinson's in others. In the nature of things we would be inclined to look for a hissing noise, and certainly the cold feeling was a feeling which I fully realised; and I am glad I made the remark as it has given Mr. Dickinson the opportunity of bringing this communication before us. With regard to the conditions under which the carbonic acid occurs in that mine, they are rather different, as far as I know, from those under which the gas occurs in coalpits. The Foxdale mine is a lead vein, containing, besides lead, a good many other minerals, and amongst them is a large quantity of spathic iron ore, and, at this level, of iron pyrites. I cannot help thinking that the carbonic acid is the result of the decomposition of the carbonate of iron—spathic iron ore—and in the conversion into peroxide the carbonic acid is given off in considerable bulk. The carbonic acid would be driven out by the sulphuric acid resulting from the decomposition of the iron pyrites. It is the only case of the kind which I have met with. There are many others, no doubt. The subject is one of much theoretical and practical interest to all who are connected with mining.

Mr. GARSIDE: The pressure you heard might have been water.

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Professor DAWKINS: I would not undertake to say what it was.

Mr. GARSIDE: In one of our mines we have had a strong feeder of water; it comes through the fissures in the rock; and yesterday, when in that particular place, I could hear a great noise—I should think 30 or 40 yards away. I thought at first it might have been gas, and I tried for it very minutely, but could not find a particle, still the noise continued. There had been a pressure of water, and the water was then breaking.

Professor DAWKINS, in reply to a question, said it was difficult to examine very minutely, but he believed the carbonic acid met with in the Foxdale mine issued from cracks.

Mr. DICKINSON: I quite concur with you that the pressure of the gas might be due to the chemical decomposition of some minerals. It is quite a common thing in some copper mines to find the heat of the workings very considerably higher than what is due to the depth from the surface; and that this decomposition is going on is quite apparent, as in some instances minerals are obtained from the water by precipitation, so that all iron work, such as tramways on the floor, and all the pump trees have to be carefully isolated from this water, the pump trees by an inner casing of wood, and the rails by being raised up above the level of the water. If an unfortunate person happens to go in with nails in his boots he will very soon find that his boots have been spoiled. This decomposition is quite common in copper mines, and in one instance which I quoted in one of my reports there was nearly being a very serious explosion in consequence of this precipitation going on. It was in the precipitating copper from the water in a very close part of one of the mines, where there was no ventilation, and but for incidentally noticing

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of this in the lengthening of the flame of a candle there would have been a terrific explosion.

Professor Boyd Dawkins: What gas, may I ask, was that?

Mr. Dickinson: It was, I should think, carburetted hydrogen. You could see it coming off in bubbles as the precipitation was going on.

Mr. Grundy: I think Mr. Dickinson's remarks with regard to percentages of carbonic acid are of importance: for a great many people who work in mines, especially those who are seeking to get mine managers' certificates, and those who have already done so, read Mr. Atkinson's book, where percentages are given, which seem to be very large as compared with those given by Dr. Angus Smith. It may act as a warning to some people to know that small per centages are injurious. In mines where I have met with carbonic acid gas I have often thought that the effect on the candle was not altogether due to carbonic acid, or perhaps not principally due to it, but largely to the absence of oxygen. I looked into Professor Thorpe's book on chemistry to see what he had said about that: he says it is found that a candle goes out in air when the oxygen falls to 18·5 per cent., and carbonic acid rises to 2½ per cent., which seems to be near the figures given by Dr. Angus Smith. I do not know of any figures giving the exact per centages of oxygen and carbonic acid compared, with the effect on a person's health, and the effect on different kinds of light. I am very much interested in the matter, and I should be glad if any one could direct my attention to figures bearing upon it.

Mr. Dickinson: I have great faith in Dr. Angus Smith's percentages He was a most careful observer. I knew him and I have sat in the little compartment of his where he made the experiments. It was fitted up for the sole purpose,

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chiefly for the Royal Commissioners then sitting on mines not within the scope of the Coal Mines Regulation Act.

A MEMBER pointed out that the difference in the percentages might have been brought about by the different degrees of purity of the carbonic acid experimented with. With pure carbonic acid, such as Dr. Angus Smith no doubt was dealing with, the quantity which would prove fatal might be very small; but in mines the gas was not, in his experience at all events, very pure. He should think the great defect in the air had been rather the want of oxygen, as Mr. Grundy put it.

Mr. GRUNDY: In several instances I have put my head in a place where the candle has been suddenly quenched without the gas affecting myself; in other cases I have held the candle or lamp about two feet above the floor and held it till the light has died out, without feeling any effects. I have done that two or three times in one day. In some cases I have been touched a little by it.

Mr. DICKINSON: If a person puts his head into or continues in a strong mixture of that kind, when it puts a light out, he is running a great risk, such as I have known to prove fatal. That it is not entirely due to the absence of oxygen can be proved by making a drill-hole into old workings; when, if you place your lamp above the hole, the light will not be affected, but if you place it below, you find it immediately extinguished. The gas pours out much the same as water.

Mr. GRUNDY: In the case I mentioned I do not want it to be understood that I thought there was no carbonic acid. I felt quite certain there was, and I found evidence of it in the roadway as well, because proceeding along with the light the effect was just as though some one had brushed the flame aside with the hand. The atmosphere of the mine was so thick it was almost like carrying the candle through treacle. If I had walked at a rapid pace the light

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would have been put out by the flame being brushed off the wick by the dense atmosphere. Others who were in the mine besides myself were comparatively little affected, even when the candle went out. I simply mention that as showing that carbonic acid was there, but that some of the effects on the candle were apparently due to want of oxygen.

A MEMBER remarked that a lamp would go out under such circumstances sooner than a candle, especially a bonneted lamp.

NOTE ON THE SEATON CAREW BORING.

BY MR. W. J. BIRD, M.E.

In the absence of Mr. Bird, Mr. Stirrup (Hon. Sec.) reported that it would probably be remembered that, in the paper read by Mr. Bird to the Society some twelve months ago, the details of the boring at Seaton Carew had been given up to 16th July, 1888 *(See Transactions, Volume XIX., page 564)*. The boring was continued until a depth of 1,814ft. 6in. had been reached, when it had to be discontinued owing to a mishap, but more to the lapse of time, as Messrs. Casebourne and Bird, were bound to have brine pumps fixed in the borehole by a certain date.

In a letter, dated 11th May, 1889, Mr. Bird writes:—

"We have now decided not to prosecute the Seaton Carew boring any further. At a depth of 1,814½ft. the tool jammed, and we have never been able to release it. We were compelled by our agreement to put in brine pumps by a certain date, so we could wait no longer. To make up for the indefinite character of the boring results we have determined to bore at Hart, half way between Seaton Carew and the most south-eastern colliery in the Durham coal field. I expect we shall start about the end of the month. The

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British Association may probably have one excursion to this boring at their Newcastle gathering."

The continuation of the Section from the 16th July, 1888, to the close of the boring is here appended :—

		ft.	in.		ft.	in.
90	Dark Grey Sandstone	6	0	..	1600	0
,,	,, ,,	3	6	..	1603	6
91	Black Shale	7	0	..	1610	6
92	Black Shale, with beds of Dark Grey Sandstone	6	6	..	1617	0
93	Black Shale	6	0	..	1623	0
94	Black Shale, with beds of Grey Sandstone	7	11	..	1630	11
95	*Coal* and Shale	0	1	..	1631	0
96	Dark Brown Fire-clay	2	0	..	1633	0
97	Dark Grey Sandstone	6	0	..	1639	0
98	Dark Shaly Sandstone	5	0	..	1644	0
90	Yellow Sandstone	8	9	..	1652	9
100	Coarse Light Grey Sandstone	16	6	..	1669	3
101	Hard Yellowish Sandstone with Lime Veinule	2	3	..	1671	6
102	Coarse Light Grey Sandstone	3	6	..	1675	0
103	Coarse Grey Sandstone	1	6	..	1676	6
104	Dark Grey Shaly Sandstone	1	6	..	1678	0
105	Black Shale	8	0	..	1686	0
106	Dark Grey Sandy Shale	3	0	..	1689	0
107	Dark Blue Shale	7	0	..	1696	0
108	Black Shale	4	0	..	1700	0
109	Dark Brown Shale	3	0	..	1703	0
110	Grey Shady Sandstone	10	0	..	1713	0
111	Coarse Grey Sandstone, with *Coal* Scars	24	0	.	1737	0
112	Dark Grey Shaly Sandstone	5	0	..	1742	0
113	Yellowish Shaly Sandstone	6	0	..	1748	0
114	Dark Shaly Sandstone	8	0	..	1756	0
115	Black Shale	24	0	..	1780	0
116	Grey Sandstone, with beds of Black Shale	10	0	..	1790	0
117	Coarse Grey Sandstone, with Black Joints	10	0	..	1800	0
118	Grey Sandstone	14	6	..	1814	6

NOTES ON BORING SECTION.

No.

27 This "Rotten Marl" Bed is the usual cover of the Rock Salt Bed of South Durham.

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30 Limestone containing 42·35 per cent. Carb. of Magnesia.
33 From this "Dark Blue Shale" there was a slight feeder of Rock Oil, and a strong feeder of Sulphur Water similar to the Croft Spa Water and which overflowed at the surface when work was suspended for a time.
38 Limestone containing 44·40 per cent. Carb. of Magnesia.
50 This Bed yielded a feeder of Saturated Brine which is still flowing.
58 At 1,340 feet the hole was contracted from 6 inches diameter to 4½ inches diameter.
59 Base of the Magnesian Limestone.
63 Coal Measures supposed to commence.
67 This Coarse Sandstone has a very close resemblance of the Northumberland 70 fathom post.
87 Fire-clay is mixed with this White Sandstone.
101 Tested by Hydrochloric Acid.
111 Very soft and friable Stone.

This boring originally begun in search of the salt beds, which were found to be absent here, was continued in the hope of piercing workable coal seams, and unfortunately had to be abandoned after entering the Coal Measures, owing to the lack of time at the disposal of the promoters.

ERRATIC BOULDERS, AND BOULDER CLAY IN CASTLESHAW VALLEY.

By Mr. W. Watts, F.G.S.

On the 5th June, 1888, I read a communication to the Manchester Geological Society on "Erratics and Boulder Clay on the Drainage area of the Oldham Corporation Waterworks," which appeared in the Transactions of 1887-88, page 584.

The ideas expressed in that communication in reference to the distribution of erratics and boulder clay in Castleshaw valley, I wish to confirm. I have, however, found a greater number and variety of boulders than I anticipated, but my remarks about clay hold good.

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Silurian Grits, Syenites, and Andesites are the most numerous class of boulders collected in the valley.

The list includes an interesting collection, and I trust ere my duties in the valley cease, others will be added.

The Granites are round and smooth, and the Silurian Grits subangular.

Striated surfaces are the exception and not the rule. The only boulder distinctly striated being a Silurian Grit about ten inches by six.

With the exception of No. 8 in my former list the largest boulders are the Syenites, two of which I found in Lee Clough 856 feet above ordnance datum, which measured 2ft. by 1ft. 8in. by 1ft. 4in., and 1ft. 10in. by 1ft. 5in. by 1ft. 5in. respectively. These erratics reposed on the margin of the stream, and doubtless had been washed down from a higher elevation. Most of them, however, are isolated, and lie buried in a coarse clayey matrix, beneath the reassorted river gravel brought down from the hills in a swollen state of the stream.

The evidence which we possess of the glacial epoch in this valley is derived from the boulders we find in it. The whole of the superficial deposits are derived from the waste of the surrounding hills, subsequent to their uprising from beneath the sea, and the erratic blocks, in my opinion, offer evidence of former glaciation, either from the transformation of the sea bottom into land, or an ice-sheet moving over it.

I am not competent to judge which, but I can readily understand that the foreign stones found in the valley may be the fragments only of larger ones, which have been broken up by subaerial agencies, and transported into the sea.

In all drainage areas in England we are more familiar with water than of ice, and we, therefore, recognise its action. But if we lived in Switzerland we should recognise with equal certainty the action of ice.

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In the upper reaches of the valley, clay of a variable character, colour, and thickness has been met with, but no boulder clay. Lower down, however, say from 730 feet to 680 feet above the sea, finely laminated marl or mud several feet thick extends across the valley under the gravel, and rises at a slight inclination towards the hills.

This marl has been wasted from the surrounding hills and formed, at no distant date geologically, a shallow lake bottom. In places the laminæ do not exceed 1-16th of an inch in thickness, and between some of the layers a burnished film of a dull red substance exists.

I have prepared a section, which illustrates these remarks better than my words.

On the rising slopes up above or about the top water level of this supposed ancient lake, yellow plastic brick or potter's clay is found. The thickness is irregular and disconnected, but this may be expected in hilly districts subject to rainwash and infiltration.

As far as I am aware in neither of these clays have any erratic boulders been found.

These are the only clays discovered above the 680ft. ordnance datum, and I do not expect any other kind will be found above Delph in Castleshaw valley.

It would appear, therefore, that the main features of the valley, or at all events the superficial deposits found in it, are of post-glacial date. With regard to the conversion of clay from shale, this valley offers, in places, unique examples. Shale clay, however, is never more than a few feet in thickness. It goes no deeper than the rainwater can percolate and sun-heat find its way. An examination of shale clays *in situ* tells us which kind of shale is suitable for the manufacture of bricks and various sorts of pottery and terra-cotta. The black colouring matter in shales is simply changed vegetable matter as mineral oil is changed coal.

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LIST OF ERRATICS FOUND IN CASTLESHAW VALLEY.

No.	Species of Boulders.
1	Andesite, Borrowdale Series?
2	Agglomerate, Borrowdale Series?
3	Ryolite, probably devitrified?
4	Sandstone, re-crystallised externally.
5	Quartzite, from the Pebble-beds.
6	Granite, Dalbeatie?
7	Andesite, same as Oxford Road Boulder.
8	Syenite, coarse-grained.
9	Silurian Grit.
10	Black Cherty Limestone.
11	Limestone Conglomerate.
12	Quartzite.
13	Iron Ore.

The first seven specimens have been named for me by Mr. Kendall, of Owens College, to whom I return my warmest thanks. The rest I have named, being well-known specimens.

Professor Dawkins, in moving a vote of thanks to Mr. Watts, said the paper was one of a kind always welcome, as evidencing great accuracy of observation in the matters referred to. The motion was recorded and passed.

Professor Dawkins said: I should like to say that off and on, in the course of my work, I have been brought face to face with the fact that these boulder clays and erratics extend to a much greater altitude in the Pennine Chain than you generally find it stated in books; and in the case brought

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under our notice you see we have a set of remains as high as from 700ft. to 800ft. Some three or four years ago I happened to be examining the Todmorden reservoir, and as far as I can remember, at about 1,000ft. (I cannot be absolutely certain of the accuracy of the figure), there was a well-defined deposit of clay in the valley, sufficiently good to be made use of for the puddling trench; and in a great many other cases higher up on the hills close to Woodhead, for instance—just on the other side of Woodhead tunnel—I have, in the course of various engineering works with which I have been connected, seen the same sort of thing; and the general impression left on my mind is that originally the greater portion, if not all, of the Pennine Chain was covered with these boulder drift deposits, and that owing to its being lifted so much above the sea level afterwards, the various atmospheric agencies have carried most of them away, leaving merely isolated masses on the slopes, and the boulders behind, which are exceedingly widely spread in certain places, at a considerable altitude. I need hardly say that it is of very great practical engineering service to know of these superficial beds in the upland valleys, for one knows what a lot of trouble is experienced by waterworks engineers by meeting with such a bed of sand as Mr. Watts has described. Once and over again I have seen frightful expenditure incurred by these filled-up valleys being hit upon, in various engineering works, in making puddle trenches and the like. I have listened with much pleasure to what Mr. Watts has had to say on these points. With regard to the boulders he has brought for our inspection, there are some—one particularly which I hold in my hand—which have come presumably from the same district, that is from Cumberland or Westmorland, like the great boulder now exhibited in the Quadrangle at Owens College. This one is of the same material, namely, andesite.

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The PRESIDENT said he quite agreed with Professor Dawkins that Mr. Watt's paper was of a kind which was most valuable, and to be relied on for its facts.

Mr. DICKINSON: I should like to ask the author of the paper and the learned Professor whether in all their examinations of the boulders which they have met—and they seemed to have been very numerous—they had not observed that in some boulders there was not the same stratification to be found as there was in the rocks when *in situ*. It is a thing which may throw some light on the formation of these boulders and gravels. It might also be considered—what gives the rounded or brecciated form to hail?—of which we had a good illustration in this district on Sunday last; and why, if you give a stone-breaker pebbles to break up, he will charge so much more per cubic yard for breaking them than if you gave him masses of rock hewn out of the quarry.

Mr. WATTS: I am not quite sure that I understand Mr. Dickinson's remarks. I may say that the boulders are rounded by the action of water and of atmospheric agencies in general. The other enquiries perhaps Professor Dawkins will answer better than I can. With reference to the breaking up of granitic boulders, I may say that I have had considerable experience of stone-breakers, and if the boulders are of suitable size for the machine, my experience tells me that a hard boulder is broken much more readily than a soft one. We have three stone-breakers at work.

Mr. DICKINSON: I was speaking of the breaking by hammer.

Mr. WATTS: Of course, in breaking by hammer, granite boulders cost a great deal more than sand-stone.

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THERMOMETRICAL OBSERVATION OF ATMOSPHERIC AIR AND WATER AT PIETHORN AND DENSHAW.

By Mr. William Watts, F.G.S.

A Committee having been appointed by the British Association to investigate the seasonal variations of temperature in lakes, rivers, and estuaries in various parts of the United Kingdom; at the request of the Secretaries of the Manchester Geological Society, I obtained permission from the Waterworks Committee of Oldham to allow the temperature of the water to be taken in two of their reservoirs under my charge.

The British Association Committee provide standard Thermometers, also printed instructions to guide the observer in his duties, and it is unnecessary to say that the instructions have been carefully followed.

The observations commenced on the 1st of January, 1889, and the daily readings are herewith presented to the Society in a tabulated form.

The remarks on the weather are brief and uninteresting to the general reader, but doubtless interesting to the meteorologist.

Each observer writes down his remarks on the state of the atmosphere to the best of his judgment. The direction of the wind in relation to the cardinal points may not in every instance be correct, owing to its deflection by the surrounding hills. The atmospheric condition at the station is noted when the thermometer is read.

The reservoir in which the observations are made at Piethorn is 823 feet above the sea level, and has an area of 40 acres; and the reservoir at Denshaw is 1,000 feet above the sea, and 25 acres. The former is in Lancashire, and the latter in Yorkshire.

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AVERAGE DAILY TEMPERATURE.

Date 1889.	Piethorn.		Denshaw.	
	Air.	Water.	Air.	Water.
January ..	36·9	37·7	36·3	36·9
February	35·0	36·3	33·6	35·7
March ..	37·7	36·4	36·6	35·9
April ..	42·6	41·0	41·6	40·5
May ..	55·1	51·1	53·1	51·2

It will be observed that both the air and water at Piethorn are warmer than the air and water at Denshaw, although the two stations are not more than 2½ miles apart as the crow flies.

The average temperature of the air is warmer than the water, at both stations.

Piethorn reservoir nestles more in the heart of the valley than Dowry reservoir, at Denshaw, and in atmospheric temperature exposure has much to answer for.

The temperature of the air during the winter months seems not to have been abnormally low at either station. The minimum reading at Piethorn occurred on the 10th of February, and on the 9th and 11th of the same month at Denshaw, when 7° of frost were registered.

The temperature of the water at each place has oscillated between 33° and 61°,—a tolerably wide range—but not exceptional for water from moorland drainage areas.

Deep-seated springs range from 37° to 40°, according to volume and seasonal changes.

In the higher reaches of the Pennine Chain the streamlets are small, and the water flowing along them is frequently

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warmer than the air, especially in winter, ; but it soon cools on exposure and agitation in the reservoirs.

The springs here alluded to are those which issue from the irregular strata on the flanks of the Pennine Chain and which have derived very little warmth from the depth from which they have risen. The strata in hilly districts are invariably cool, and equable, owing to the beds cropping out in the ravines and rising slopes. Temperature is not a sure indication of depth as some springs are very little above the freezing point, whilst others reach the boiling point of water. With regard to the flow of moorland streams in summer the volume of water is not only considerably reduced by evaporation in the middle of the day, but highly heated by the heat rays from the sun and radiant heat from the shingle.

(See the daily readings on the next and following pages.)

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS PIETHORN.

Date 1889.	Hour.	Temperature.		Remarks on Weather.	
		Air.	Water.		
Jan. 1	9 a.m.	37·0	39·0	Fine, very Foggy	W.
,, 2	,,	36·0	39·0	,, ,,	N.W.
,, 3	,,	35·0	37·0	,, ,,	S.W.
,, 4	,,	30·2	37·9	Fine and Clear	S.W.
,, 5	,,	30·4	36·7	,, ,,	W.
,, 6	,,	29·0	36·4	Fine and Foggy	W.
,, 7	,,	35·1	36·9	,, ,,	W.
,, 8	,,	37·0	37·5	,, Dull	S.W.
,, 9	,,	42·5	39·0	,, ,,	S.W.
,, 10	,,	37·6	37·8	Fine, very clear	N.W.
,, 11	,,	35·2	37·4	,, ,,	S.E.
,, 12	,,	33·0	37·8	Sleet and Rain	E.
,, 13	,,	36·3	37·4	Rain and Dull	N.E.
,, 14	,,	38·0	37·1	Fine ,,	N.E.
,, 15	,,	35·1	36·9	,, ,,	S.E.
,, 16	,,	34·0	37·4	Snow Storms	N.E.
,, 17	,,	37·0	37·3	Fine and Dull	S.W.
,, 18	,,	36·3	38·0	Rain ,,	S.W.
,, 19	,,	38·4	37·8	Fine ,,	S.W.
,, 20	,,	39·0	38·0	,, ,,	N.E.
,, 21	,,	38·8	37·8	Fine and Clear	N.E.
,, 22	,,	35·2	37·1	,, ,,	N.E.
,, 23	,,	34·8	37·4	Fine and Foggy	W.
,, 24	,,	40·9	37·9	,, Dull	N.W.
,, 25	,,	41·0	38·0	,, ,,	N.W.
,, 26	,,	43·4	38·8	Rain and Dull	N.W.
,, 27	,,	31·0	38·0	Fine and Clear	N.E.
,, 28	,,	40·1	37·9	,, Foggy	S.W.
,, 29	,,	44·0	38·6	Rain and Dull	S.W.
,, 30	,,	38·9	37·9	,, ,,	S.W.
,, 31	,,	45·0	39·0	,, ,,	S.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.	
		Air.	Water.		
Feb. 1	9 a.m.	48·5	40·0	Rain and Dull	S.
,, 2	,,	33·0	38·8	Snow and Hail	N.W.
,, 3	,,	36·9	38·1	Fine and Clear	N.W.
,, 4	,,	33·6	37·0	,, ,,	W.
,, 5	,,	32·8	36·0	Snow and Foggy	S.
,, 6	,,	39·1	38·8	Fine and Dull	N.W.
,, 7	,,	33·0	37·0	Snow Fall	N.E.
,, 8	,,	42·4	37·3	Rain and Dull	S.W.
,, 9	,,	28·1	38·0	Fine and Clear	N.W.
,, 10	,,	25·0	34·0	,, ,,	E.
,, 11	,,	26·7	34·0	Snow Fall	N.E.
,, 12	,,	28·0	33·1	Fine, Very Clear	N.E.
,, 13	,,	34·0	34·0	Snow and Dull	S.
,, 14	,,	40·1	35·2	Rain	W.
,, 15	,,	34·3	35·1	Slight Snow Fall	W.
,, 16	,,	34·5	35·0	Fine and Dull	S.
,, 17	,,	44·0	35·9	Rain and Snow	S.W.
,, 18	,,	45·7	37·2	,, Dull	S.W.
,, 19	,,	40·9	39·8	Fine ,,	S.W.
,, 20	,,	40·0	39·0	,, ,,	S.W.
,, 21	,,	56·3	36·0	Showery ,,	N.W.
,, 22	,,	35·0	35·7	Fine ,,	N.W.
,, 23	,,	31·3	36·2	Slight Snow Fall	E.
,, 24	,,	31·4	35·1	Fine and Clear	N.
,, 25	,,	32·2	34·0	,, ,,	N.E.
,, 26	,,	32·0	36·0	Slight Snow Fall	N.E.
,, 27	,,	31·8	35·3	,, ,, ,,	N.W.
,, 28	,,	29·3	35·7	Snow and Dull	N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.	
		Air.	Water.		
March 1	9 a.m.	27·3	35·1	Snow and Dull	N.E.
,, 2	,,	28·8	35·0	Fine and Clear	S.E.
,, 3	,,	28·0	34·9	,, ,,	E.
,, 4	,,	29·0	34·4	,, ,,	E.
,, 5	,,	30·4	34·6	Fine and Dull	S.E.
,, 6	,,	35·7	34·8	,, ,,	S.
,, 7	,,	34·3	34·9	Slight Snow Fall	N.E.
,, 8	,,	36·0	35·1	,, ,,	N.E.
,, 9	,,	34·9	35·0	Heavy ,,	S.W.
,, 10	,,	35·5	34·9	Fine and Clear	S.W.
,, 11	,,	38·2	34·4	,, ,,	N.E.
,, 12	,,	43·3	34·9	Rain and Dull	S.W.
,, 13	,,	43·3	35·9	,, ,,	S.W.
,, 14	,,	39·0	36·3	Fine and Clear	N.W.
,, 15	,,	35·5	36·0	,, ,,	S.E.
,, 16	,,	41·3	36·8	Fine and Dull	N.W.
,, 17	,,	42·5	37·0	Rain ,,	N.W.
,, 18	,,	39·6	37·0	,, ,,	S.W.
,, 19	,,	42·0	37·0	Fine and Clear	S.E.
,, 20	,,	36·8	35·4	Snow and Rain	S.W.
,, 21	,,	33·6	36·7	,, Dull	N.E.
,, 22	,,	31·6	35·3	Slight Snow and Dull	N.E.
,, 23	,,	40·2	37·0	Fine and Dull	S.W.
,, 24	,,	47·0	38·4	Rain ,,	S.W.
,, 25	,,	44·0	38·9	,, ,,	W.
,, 26	,,	39·8	38·5	Fine ,,	W.
,, 27	,,	37·0	37·6	Fine and Clear	N.E
,, 28	,,	38·8	38·2	,, Dull	S.W.
,, 29	,,	47·4	39·8	Slight Rain and Dull	S.W.
,, 30	,,	46·5	40·0	Fine and Dull	S.W.
,, 31	,,	41·6	40·0	Slight Rain and Dull	N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.
		Air.	Water.	
April 1	9 a.m.	41·6	39·9	Slight Rain and Dull N.W.
,, 2	,,	38·9	39·6	Fine and Clear N.W.
,, 3	,,	37·9	38·9	Fine and Dull S.W.
,, 4	,,	45·7	40·1	Slight Rain and Snow S.E.
,, 5	,,	40·3	40·1	Heavy ,, E.
,, 6	,,	41·9	40·2	,, ,, E.
,, 7	,,	36·6	40·3	,, ,, E.
,, 8	,,	36·9	40·0	,, ,, E.
,, 9	,,	36·8	39·9	Slight Rain and Dull E.
,, 10	,,	39·3	39·7	,, ,, E.
,, 11	,,	39·1	39·9	,, ,, Snow E.
,, 12	,,	40·7	40·1	Slight Rain and Hail N.E.
,, 13	,,	40·8	40·0	,, ,, N.E.
,, 14	,,	37·5	39·6	Slight Snow Fall N.E.
,, 15	,,	41·3	40·0	Fine and Clear W.
,, 16	,,	45·3	40·1	,, Dull S.W.
,, 17	,,	49·0	41·3	,, ,, W.
,, 18	,,	48·3	41·8	,, Clear N.W.
,, 19	,,	45·7	42·0	,, Dull S.W.
,, 20	,,	47·2	41·9	Slight Rain and Dull W.
,, 21	,,	40·5	41·9	,, ,, W.
,, 22	,,	44·7	41·9	Heavy Rain and Hail S.W.
,, 23	,,	43·2	41·8	Fine and Clear S.W.
,, 24	,,	40·9	41·9	Heavy Rain and Hail N.E.
,, 25	,,	42·0	42·0	Slight ,, N.E.
,, 26	,,	46·0	42·1	Fine and Clear S.W.
,, 27	,,	47·0	43·4	Heavy Rain S.
,, 28	,,	51·3	43·3	Fine and Clear S.W.
,, 29	,,	48·3	43·6	Heavy Rain S.
,, 30	,,	45·1	43·5	Slight ,, N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.	
		Air.	Water.		
May 1	9 a.m.	44·8	43·6	Heavy Rain	S.W.
,, 2	,,	49·0	44·7	Fine and Clear	E.
,, 3	,,	50·6	44·6	,, ,,	S.
,, 4	,,	61·0	45·0	,, ,,	S.E.
,, 5	,,	54·1	46·0	,, ,,	N.E.
,, 6	,,	59·1	48·4	,, ,,	E.
,, 7	,,	62·9	49·0	,, ,,	E.
,, 8	,,	50·5	49·9	Slight Rain	S.W.
,, 9	,,	52·7	48·8	,, ,,	N.E.
,, 10	,,	51·0	49·9	,, ,,	S.
,, 11	,,	46·3	50·1	Heavy Rain	N.
,, 12	,,	50·2	49·9	Slight Rain	N.
,, 13	,,	47·2	49·6	,, ,,	N.E.
,, 14	,,	46·3	49·6	Fine and Dull	E.
,, 15	,,	51·3	49·6	,, ,,	N.E.
,, 16	,,	61·8	54·0	,, ,,	N.W.
,, 17	,,	50·3	49·9	,, ,,	N.E.
,, 18	,,	58·9	50·7	Fine and Clear	N.E.
,, 19	,,	56·6	52·0	Slight Rain	N.E.
,, 20	,,	64·2	52·9	Fine and Clear	N.E.
,, 21	,,	69 0	54·3	,, ,,	E.
,, 22	,,	69·5	54·9	,, ,,	S.E.
,, 23	,,	64·9	58·6	Slight Rain	S.W.
,, 24	,,	64·0	58·4	,, ,,	S.W.
,, 25	,,	51·4	57·3	Heavy Rain	N.W.
,, 26	,,	54·9	56·6	Fine and Clear	N.E.
,, 27	,,	50·0	52·5	,, ,,	E.
,, 28	,,	51·6	53·0	Heavy Rain and Dull	S.
,, 29	,,	53·9	53·6	Slight Rain	S.W.
,, 30	,,	53·3	53·6	,, ,, and Hail	S.
,, 31	,,	56·9	53·3	,, ,,	S.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.

Date 1889.	Hour.	Temperature.		Remarks on Weather.
		Air.	Water.	
Jan. 1	9 a.m.	37·2	36·3	Fine and Dull S.W.
,, 2	,,	35·8	36·4	,, ,, S.W.
,, 3	,,	33·5	36·7	Bleak, Frosty, & Misty S.W.
,, 4	,,	30·4	36·6	,, ,, W.
,, 5	,,	30·0	37·0	,, ,, S.W.
,, 6	,,	28·2	36·8	,, ,, N.W.
,, 7	,,	33·4	36·6	Thick Fog and Cold S.W.
,, 8	,,	36·7	37·0	Cold Wind and Dull S.W.
,, 9	,,	43·0	37·4	,, ,, Stormy S.W.
,, 10	,,	35·6	37·4	,, ,, Fine N.W.
,, 11	,,	35·2	37·3	,, ,, ,, N.W.
,, 12	,,	32·0	37·1	Sleet and Frosty E.
,, 13	,,	34·2	37·0	,, ,, N.E.
,, 14	,,	36·0	36·8	Cold Wind and Frosty N.E.
,, 15	,,	33·8	36·6	,, ,, ,, N.E.
,, 16	,,	33·0	36·5	,, ,, Snow S.E.
,, 17	,,	37·1	36·5	Cold, Thick Fog S.W.
,, 18	,,	45·0	36·7	Cold Wind & Stormy S.W.
,, 19	,,	36·2	37·1	,, ,, S.W.
,, 20	,,	38·7	37·2	Fine and Cold N.E.
,, 21	,,	38·0	37·0	,, ,, N.E.
,, 22	,,	34·2	36·9	,, Frosty E.W.
,, 23	,,	33·0	36·0	Frosty and Misty E.W.
,, 24	,,	40·0	37·2	Cold ,, N.W.
,, 25	,,	40·3	37·3	Dull and Stormy W.
,, 26	,,	43·0	37·5	,, ,, W.
,, 27	,,	32·6	36·7	Frosty and Cold E.
,, 28	,,	38·2	37·1	Cold Wind & Stormy S.W.
,, 29	,,	42·3	37·5	,, ,, S.W.
,, 30	,,	37·2	37·6	,, ,, S.W.
,, 31	,,	44·4	38·0	,, ,, W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.
		Air.	Water.	
Feb. 1	9 a.m.	47·0	38·6	Misty and Stormy W.
,, 2	,,	31·2	38·7	Frosty & Snowstorms N.W.
,, 3	,,	34·9	38·1	,, Cold Wind N.W.
,, 4	,,	32·5	37·0	,, ,, N.E.
,, 5	,,	33·0	37·0	,, ,, S.W.
,, 6	,,	37·0	37·0	Dull ,, W.
,, 7	,,	33·0	36·8	Rough Wind & Stormy N.E.
,, 8	,,	41·2	36·8	,, ,, ,, N.W.
,, 9	,,	25·3	35·7	Keen Frost and Cold N.E.
,, 10	,,	26·4	34·0	,, Snow E.
,, 11	,,	25·8	33·7	,, Fine N.E.
,, 12	,,	26·0	33·6	,, ,, N.E.
,, 13	,,	31·6	34·1	Cold Wind and Snow S.E.
,, 14	,,	38·2	34·6	,, Dull W.
,, 15	,,	33·6	34·7	,, Frosty N.W.
,, 16	,,	32·0	34·0	Keen Frost and Snow S.W.
,, 17	,,	40·1	34·9	Dull and Stormy W.
,, 18	,,	44·2	35·4	,, ,, W.
,, 19	,,	39·8	36·1	,, Fine W.
,, 20	,,	40·0	36·4	,, Stormy W.
,, 21	,,	34·5	36·0	Frosty and Cold Wind N.
,, 22	,,	33·0	35·8	,, ,, W.
,, 23	,,	29·9	35·7	Keen Frost and Cold N.E.
,, 24	,,	31·0	35·3	,, ,, N.E.
,, 25	,,	29·9	35·1	,, ,, N.E.
,, 26	,,	29·6	35·0	,, ,, E.
,, 27	,,	34·0	35·0	,, Snow N.
,, 28	,,	27·0	34·8	,, ,, E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.
		Air.	Water.	
March 1	9 a.m.	28·2	34·8	Keen Frost and Snow N.E.
,, 2	,,	26·3	33·9	,, ,, Fine E.
,, 3	,,	29·1	33·8	,, ,, ,, E.
,, 4	,,	28·3	33·5	,, ,, ,, E.
,, 5	,,	28·6	34·1	,, ,, ,, S.
,, 6	,,	33·4	34·6	,, ,, ,, S.W.
,, 7	,,	33·0	34·3	,, ,, ,, E.
,, 8	,,	33·2	34·4	Rough, Snow Storms N.E.
,, 9	,,	35·1	34·4	Keen Frost and Fine N.
,, 10	,,	34·0	34·5	,, ,, ,, S.W.
,, 11	,,	33·2	34·3	Dull and Stormy N.E.
,, 12	,,	35·8	34·6	,, ,, W.
,, 13	,,	41·5	35·2	,, Fine W.
,, 14	,,	41·0	35·7	Frosty and Cold N.W.
,, 15	,,	34·5	35·6	,, ,, E.
,, 16	,,	40·5	36·0	Dull and Cold Wind W.
,, 17	,,	42·4	36·4	,, Stormy W.
,, 18	,,	39·8	36·8	,, ,, S.
,, 19	,,	39·9	36·9	,, ,, S.
,, 20	,,	34·0	37·0	Snow ,, N.W.
,, 21	,,	32·3	36·2	Keen Frost and Fine N.E.
,, 22	,,	31·0	35·9	,, ,, ,, N.W.
,, 23	,,	37·0	36·4	Dull and Stormy W.
,, 24	,,	45·7	37·0	,, ,, W.
,, 25	,,	45·9	37·6	,, ,, W.
,, 26	,,	38·7	37·9	Fine and Frosty N.W.
,, 27	,,	35·0	37·5	Frosty and Cold Wind N.W.
,, 28	,,	35·5	37·8	,, ,, S.W.
,, 29	,,	49·6	38·3	Dull and Fine W.
,, 30	,,	45·7	39·0	,, Stormy W.
,, 31	,,	48·0	39·3	,, ,, W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

Date 1889.	Hour.	Temperature.		Remraks on Weather.
		Air.	Water.	
April 1	9 a.m.	40·2	39·3	Dull and Cold Wind W.
,, 2	,,	38·6	39·3	,, ,, N.W.
,, 3	,,	38·3	39·4	,, ,, S.W.
,, 4	,,	43·0	39·7	Dull and Stormy S.
,, 5	,,	42·0	39·8	Cold Wind and Stormy N.E.
,, 6	,,	38·5	39·7	,, ,, E.
,, 7	,,	36·7	39·8	Cold Wind and Snow E.
,, 8	,,	35·2	39·3	,, ,, E.
,, 9	,,	36·0	39·1	,, ,, E.
,, 10	,,	37·2	39·0	,, ,, E.
,, 11	,,	37·2	39·0	,, ,, E.
,, 12	,,	39·3	39·2	,, ,, E.
,, 13	,,	44·0	39·3	,, ,, E.
,, 14	,,	36·4	39·1	Cold Wind and Fine W.
,, 15	,,	40·0	39·2	,, ,, N.W.
,, 16	,,	41·5	39·4	Dull and Fine W.
,, 17	,,	46·7	39·8	,, ,, W.
,, 18	,,	49·6	40·4	Dull and Stormy W.
,, 19	,,	45·1	40·9	Cold Wind and Stormy S.W.
,, 20	,,	45·4	41·1	,, ,, W.
,, 21	,,	41·5	41·3	,, ,, W.
,, 22	,,	42·0	41·4	,, Thunder W.
,, 23	,,	43·2	41·6	,, ,, N.E.
,, 24	,,	39·6	41·6	,, Fine N.E.
,, 25	,,	39·4	41·8	,, ,, N.E.
,, 26	,,	42·8	42·0	,, Stormy S.W.
,, 27	,,	47·2	43·0	,, Fine W.
,, 28	,,	49·1	43·4	,, Stormy S.
,, 29	,,	49·0	43·9	,, Fine S.
,, 30	,,	43·4	43·8	,, Stormy E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

Date 1889.	Hour.	Temperature.		Remarks on Weather.
		Air.	Water.	
May 1	9 a.m.	43·1	43·7	Cold Wind and Stormy S.W.
,, 2	,,	52·0	44·0	Fine and Warm E.
,, 3	,,	49·0	44·3	,, ,, S.
,, 4	,,	57·6	45·2	,, ,, S.E.
,, 5	,,	50·4	46·0	,, ,, S.E.
,, 6	,,	52·3	47·3	,, ,, E.
,, 7	,,	51·5	48·0	Dull and Stormy E.
,, 8	,,	50·1	48·6	Fine and Dull S.
,, 9	,,	48·5	49·2	Dull and Stormy E.
,, 10	,,	49·8	49·5	,, ,, W.
,, 11	,,	46·9	49·2	,, ,, W.
,, 12	,,	49·0	49·3	,, ,, E.
,, 13	,,	46·4	49·5	,, ,, E.
,, 14	,,	45·0	49·0	Fine and Warm E.
,, 15	,,	49·8	49·4	,, ,, S.E.
,, 16	,,	56·0	50·1	,, ,, E.
,, 17	,,	49·0	50·5	Fine and Dull E.W.
,, 18	,,	57·3	51·3	,, ,, W.
,, 19	,,	56·0	52·2	Fine and Warm E.
,, 20	,,	61·2	54·1	,, ,, E.
,, 21	,,	64·4	56·0	,, ,, E.
,, 22	,,	70·0	57·4	Showery, Thunder S.
,, 23	,,	64·9	59·5	,, ,, W.
,, 24	,,	61·5	61·0	,, ,, S.W.
,, 25	,,	55·5	59·4	,, ,, W.
,, 26	,,	53·0	58·3	Dull and Fine E.
,, 27	,,	48·4	54·6	,, Stormy E.
,, 28	,,	49·0	53·0	,, ,, S.W.
,, 29	,,	51·8	53·3	Thunderstorms S.
,, 30	,,	52·9	53·2	,, S.W.
,, 31	,,	53·2	53·0	,, S.W.

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A vote of thanks having been passed to Mr. Watts.

Professor DAWKINS said there was one point upon which he would like to ask a question. Mr. Watts said that the deep-seated springs had a temperature ranging from 37 to 40 degrees. That was contrary to all his (Professor Dawkins's) experience with regard to deep-seated springs. The deeper seated the spring, as a rule, the warmer was the water, and it was so universally the case, so far as he knew, that they could form a rough counting estimate by the temperature of the water as to the probable depth from which the water rose swiftly to the point of supply. In this district they found a temperature of about 50 degrees at about 40ft. below the surface of the ground—that agreed with the temperature of the rock; and of course the temperature of the water was ultimately derived from the rock, and the deeper you go into the rock the warmer it became. Hence the deeper seated the spring the higher would the temperature probably be. He would therefore like to ask Mr. Watts whether there were any special facts which stood in relation to those deep seated springs which he had described as being of 37 to 40 degrees.

Mr. WATTS said the springs were situated in Swineshaw Valley, about three miles from Stalybridge. He resided there during the construction of the water works, and as the valley was very prolific of springs—one of the most prolific in the Pennine Chain for its size—he took great interest not only in gauging these springs for years, but in taking the temperature, and the results were presented in this paper. Perhaps he went a little beyond the mark in speaking of them as deep-seated springs, but for springs situated in the Pennine Chain they were deep-seated.

Professor DAWKINS said he was glad to hear what Mr. Watts had said. Deep-seated springs were practically of

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the same temperature in summer and winter, while in superficial water they found of course considerable variation.

The meeting then adjourned for a short time.

At 6-30 p.m. the members re-assembled.

Mr. SAINT, one of Her Majesty's inspectors of mines, was called to the chair, in the absence of the President.

SOME NOTES ON THE BARTON SECTION OF THE MANCHESTER SHIP CANAL.

BY MR. CHARLES ROEDER.

The Barton-upon-Irwell section of the ship canal, in consequence of various valuable discoveries made from time to time bearing upon the geology, botany, and archæology of the locality in general, has recently attracted an unusual amount of public attention. Speculations have been rife and theories and hypotheses have been advanced to solve some of the problems which are involved. It has appeared to me worthy of interest to inquire a little into the topography of the place itself and its immediate neighbourhood, and to see what side lights could be thrown by an examination of ancient records, and such sources of information of which I have been able to avail myself, and I hope the evidence afforded by an examination of the various material I have to bring forward will assist us not a little to arrive at some conclusion or other as to the possible age of the objects which have been found during the excavations effected at Salt Eye and Sticking Islands.

I have also brought some of the older maps, which will allow you to examine the change of direction of the rivers and watercourses with which we have to deal. It would have been a great gain if I could have had access to the

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older surveys, held, no doubt, by the ancient proprietary families of the district, as the Leighs, Traffords, Egertons, and Booth, as the field and place names these terrars contain could throw much light upon the former physiography of the district under consideration. The first glimpse allowed to us brings us to the time of the Roman occupation, and the late W. Th. Watkin, in his "Roman Lancashire," which I have placed on the table for inspection of the maps, states that a branch road existed, passing through the northern part of Trafford Park to the "street" (or Higher Croft) in Barton, thence by the "streetfields" (a complex of four meadows, lying in succession along the northern border of the Irwell, and marked on the 6 inch Ordnance Map, which I also produce) in a S.W. direction, by Irlam, Cadishead, and near Statham to the Roman Station at Wilderspool, near Warrington. Coins found at Statham, a bronze metope at Risley Moss, and a bronze colander attest, according to him, its route; but the immense mosses of Chat Moss, Risley Moss, and Carrington Moss, which he opines, are in a great measure, though not perhaps entirely, of post-Roman formation, have completely obliterated its course.

In 1875, he says, Mr. E. Kirk, of Eccles, reports "that in constructing a main sewer for the Eccles and Barton Board of Health, the workmen struck upon an old ancient roadway, about a quarter of a mile from Barton Old Hall, and in a direct line with the old ford at Barton, the site of which is about 400 yards down stream from the present bridge. The sewer being brought along what has been formerly a piece of forest swamp, in which the trunks of oak and other trees were found in a thick bed of vegetable matter. The old causeway, which was intersected at right angles, was about 4½ feet below the surface, the pavement was of stone, about the size lately common in street foot-

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paths, 18 inches wide, and rose bow-like about 9 inches in the centre. The stones were fixed in a thick layer of sand, which rested upon a bed of brushwood laid upon the peaty matter. The causeway was about 13 feet west of the present highway, which is a very old one, and there is nothing on the surface to cause suspicion of a former road existing."

The Roman road from Barton to Wilderspool is traced on Watkin's map and crosses the northern river curve at Barton twice between this village and Irlam, and possibly another road passed from Barton at right angles to Cross Street at Stretford.

Unfortunately the continuation of the road, mentioned by Kirk, to the old ford at Barton, which the excavations may have laid bare or shown, for not having been attended to at the time the cutting was begun, has not been traced and thus a good opportunity of further discoveries in that direction missed and neglected.

The next notice we possess of Barton is contained in Harland's "Mancestre," in the Inquisition of 1282. It speaks of the herbage and pannage of the wood worth 9s., and a certain fishing worth yearly 18s. In the "Extent" of 1322 we read (Vol. ii. p. 394) "at Barton (there is) a several fishery in that place from Barton ford as far as into the Frith ford worth yearly 8d., and there are there 4 fixed ferries and a plot of pasture which Robert Grelle inclosed from the bank for hay and for building on. And which plot is reckoned and is let for a term, with the arable land upon which the fishery is founded, and is worth 12s. At that time there were 15 messuages in Barton. Of moor or heath land we have Bromyhurst (= Broomyhurst heath), 120 acres; Whyte moss, 10 acres; Hulme Moss (Davy Hulme); Hagmoss, 20 acres; Halmoss, 12 acres turbary; Pulle greenes (Peelgreen), 1 acre pastur-

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age; Boysnape, 12 acres pasture; and it mentions the wood of Boye-snape and Lostock, in which grow oaks, hazels, thorns, and such like." Coming to Chat moss it says: "It is the soil of the lord of Barton, Worselegh, Astley, Workedlegh, Astley and Bedford. The wood being undivided is not measured, because there is so small a goodness contained in so large an extent in which (wood) all the tenants of the said lords have common of turbary, but the yearly profit of the said moor is not extended by reason that the little goodness of the premised commons gradually grows less."

Baines in his history of the "Palatinate of Lancaster" states that originally Chat Moss was an immense forest, but became reduced to an extensive bog at a remote period. The trees found are birch, oak, fir (?), and most of them charred on the exterior, "indicating that they must have fallen under the operation of fire, rather than by the stroke of the woodman." They generally lie from west to east. The objects found in it were a leather shoe of peculiar make; a cow's horn, of a breed of cattle now extinct; and, according to Whitaker, "an ancient beehive, which, on touching, fell into dust." The moss is 5 miles long, from east to west, and Baines thinks that the forest must have disappeared before the Norman Conquest, as the Doomsday-book gives to Salfordshire, including Horwich and Blackley, a forest stretch of only $7\frac{1}{2}$ miles in length and $5\frac{1}{4}$ miles in breadth.

Chat Moss rests on the boulder clay, which, as sections have shown, is variously overlaid with loamy sand and silt. Mr. W. Brockbank, in an interesting communication made to the Literary and Philosophical Society of Manchester, Vol. V., 1861, mentions that the clay is capped at Astley Station by a seam of loamy sand, containing roots and stumps of oak, birch, and hazel, the stumps being broken

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off about a foot from the surface and the trees lying near, embedded in the moss. He supposes that the level valley on which the Moss now lies was formerly covered over with a forest of oaks, with a dense undergrowths of birch, hazel, and other brushwood. How the forest became covered with Moss he leaves an open question, but thinks the cause of the gradual decay owing to the low-lying undrained ground.

Baines suggests that Chat Moss may derive its name from St. Chad or Ceadda, Bishop of Mercia in 669; but whether the parallel holds good, and whether he really owned it or not, or had his name given to it, we cannot say, as records are silent about this point. No doubt it must have undergone a deal of early clearing and deforestation, as we have learned already the "wood" remaining at the time of the Inquisition of 1322 is "not measured because there is so small a goodness contained in so large an extent." Nowhere is there any mention of either chase, park, or forest there in the early accessible records relating to the Manor of Barton. As regards the origin of the name of Ceaddas Moss, I am rather inclined to think that it indicates the existence of a former Celtic occupation, and that long before the supposed St. Chad or Ceadda the appelation was given by a Kymrian branch and that it simply means and stands for "wood" par excellence, that is "the" forest. We have the Welsh "coed," synonymous with wood or trees. Near Manchester we meet with Cheetwood, which Harland would derive from Cedde, a Saxon male name, but which to me appears to be a mere tautology, being "coed-wood," and uniting the compound Celtic and Saxon roots. At the South-west corner of Chat Moss stands Cadishead (Cade-wele-sate and Cade-wels-hed in 1230), which formerly was held by the service of carpentry. The boundary of the Hundred coincides with and runs along the Gless or Glazebrook (in times past a

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more important water course, whose bed has experienced great changes, as the maps seem to demonstrate), the name of which equally has a Celtic face, and answers most probably to the Welsh "Glass," a stream of a greenish blue colour.

If we now accept this view or not, from what has been shown in the course of my earlier remarks, it seems that we are led to the conclusion that the Barton district points to very venerable lineage, and it may not be wrong to suppose that a not unimportant communication or a vicinal track must have existed long before the advancing Roman columns formed their network of military roads, and that they probably incorporated the same in constructing the road running along the border of the river and the skirts of the present "Chat Moss," or even cutting through it.

Returning now again to Frithford, there is a point which deserves consideration in connection with the discovery of the ancient canoe at Salt Eye. On examination of the 6in. Ordnance Map we find that near the junction of Sticking's Cut, where the river takes up a northernly turn, forming itself into a double loop, on the south side of the channel there occur three distinct plots of land, belonging respectively to the ancient Hamlets of Dumplington, Bromyhurst and Davyhulme (formerly Hulme, and first mentioned Davy Hulme in 1558). Bromyhurst and Dumplington proper are situate away to the north and east and Davyhulme to the south of the river, and the group in question forms a detached block. To me this combination implies that that circumstance would be due to the existence of ancient and separately conferred ferry rights, and that possibly it marks the former position, not only of the Frithford of 1322, but furnishes likewise traditional evidence of an older, perhaps Roman or Pre-Roman ford, and that we have to take notice of this fact in attempting to account for the situation and circumstances under which the canoe has been found. It

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would tally with this striking concurrence. We have seen that there were *four ferries fixed at that ford in 1322* (and probably long before), there were only 15 houses occupied by dependents of the manor of Barton and the ferry-transit between Cheshire and Lancashire, and for passing in and out of the counties, point to some sort of importance with regard to this place. This naturally brings me to speak of the actual and former course. The Irwell itself, and its double loop at Salt Eye, which at its second northernly bend receives the Salt Eye Brook, higher up called Worseley Brook. That the many moss movements and great floods and inundations (even if we speak of the few that have really been recorded) must have interfered considerably in past times with its direction and level, is a proposition we may readily grant. Leland in 1538 informs us that Chately Moss (Chat Moss) "with breaking up of abundance of water in it did much hurt to lands thereabout, and rises with wandering mosses and corrupted water. It destroyed much ground with moss thereabout, corrupting with stinking water Glasbroke, and so Glasbroke carried stinking trees, and Mersey corrupted carried the rolling moss. In the very top of Chaw Moure (Chat Moss) where the moss was highest and broke, is now a fair plain valley, *as was in time past*, and a rill runs in it and pieces of small trees be found at the bottom of it." Indication of such travelled shoals of bog and moss masses, often of frightening dimensions, have been revealed in various parts of the Barton sections. In their onward movement they uprooted and carried large trees and scrubwood before them, damming and blocking the flow of the river, and striking it at right angles, thus leading to the formation of new channels, pools and boggy ground, and I think it is to conditions of such a nature that the delineation of the alluvial structure at the junction at Glazebrook and the Irwell down to Rixton Old Hall, as shown

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in the geological map referring to the locality is possibly due. The accumulation of underground water also must have been assisted in a great measure by the underlying boulder clay spreading as it does, and as proved, in ridges and long undulations while the surface water which made its way from the elevated ground to the North of Barton, etc., would be easily taken up and filtered through the capping sands and gravels. Camden in his "Britannia," relates the eruption of moss similarly to Leland, but perhaps copied from the former. 1633, Hollingworth speaks of a moss of great breadth of 4 or 5 yards deep, carrying large trees down and filling the brooks and river, which from some evidence I conclude must have been at Strangeways, near the Medlock and Irk. Of inundations and great floods we have many records, and very disastrous ones too, as in 1616, 1649, 1767, 1768, 1787, 1799, to mention only some instances occurring in the last two centuries. If we can trust Saxton's map, done by actual survey under the assistance of "several engineers" [I refer to his map of 1610, in Camden's Britannia], there has been a striking change in the course of the river bed of the Irwell from Barton to its conjunction with the Mersey; the same is patent from Speed's map of 1610, and Janssen's map of 1647. Ogilby's survey of 1698 (showing the roads of the kingdom) gives a very minute trace of the river at Barton, and there is an absence of the double loop, and from a comparison of the various maps alluded to, it seems that the formation of these bends must be of comparatively recent date, and that the river had a more westerly trend. Of course it might be objected to that we must not be too critical with these old maps, but even then the general impression of the direction of this river remains in favour of assuming a great swinging, effected since in a contrary direction. I think I have some evidence to show that the

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river has suffered a change in the course of the last few centuries at Barton in a line from the aqueduct to Stickings Lock. At the entrance of the works at Barton, on its southern corner, we see the outcrop of the Trias on which we have a deposit of middle-sized, worn river gravels, which are overlaid again by a considerable mass of brown, loamy river silt. From the gravels resting immediately on the rock floor I have extracted various pieces of rolled, burned clay and a fragment of double glazed (in and outside) pottery, and the same again lower down at Sticking Island, also from the bottom gravels, about the middle of the section. As the river at present near the entrance of the works runs some appreciable distance away to the south of the cutting, while at Sticking Island the curve is keeping away to the north, and I think it follows that the river since then retreated at the aqueduct point to the south, and that at Sticking Island the sling must have been of later time to the deposition of this piece of pottery, as the cuttings run diametrically to the south of it through the "Eye," where we have now *terra firma*, and that the channel probably assumed an almost westerly flow.* To understand this, I place before you the Map of the Ship Canal Project, attached to Palmer's Report of 1840.† As to the particular date of the pottery I have been informed by Mr. Augustus W. Franks, of the British Museum, and to whom I am indebted, and to whom I have submitted the matter, that the Saxons never, to his knowledge used any glaze inside; the Romans very rarely employed glaze, and then only in vessels of an ornamental character, of which not half a dozen have been found in this country, and that if the pottery is glazed, there is every probability of its being mediæval or modern, but that

* Or the present northerly sling at Stickings was before quite to the south, and instead of being a curve ran straight.

† Where I have marked with dots are the places where pottery was found.

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it is impossible to give any date to broken pottery, unless they have some ornament. The only conclusion therefore, which remains to us, is that the range of possibility is from a mediæval period to more recent times, and the latter view is perhaps the most acceptable in connection with the projection of the later maps. I have not touched to-day—not to make the communication too long or too irksome—the few remarks I intended to bring forward about some geological observations I have made while visiting this particular section, and I shall return to the discussion of this matter at a later time.

The Hon. Secretary read a note forwarded by Mr. Dickinson with regard to the place called Salt Eye. It was an extract from Mr. Dickinson's Report, 1881, to Secretary of State, on the Salt Districts.

"In the hamlet of another Barton, five miles west of Manchester, the lower part of Worsley Brook is called Salteye Brook, and the land at the east side, where the brook enters the river Irwell, is called Salteye or Salteea Orchards; but if the names were taken from any ancient brine springs, all trace of them seems lost."

Mr. Mark Stirrup moved a vote of thanks to Mr. Roeder (whose paper was read in his absence), remarking that he had evidently bestowed upon it a great amount of time and research. Some of the evidence he had brought forward might assist them in arriving at a correct conclusion concerning some of the theories advanced to account for the age of the Barton canoe, of which he had shortly to speak.

Mr. Grundy said he had much pleasure in seconding the vote of thanks.

The motion was passed unanimously.

Mr. Percy F. Kendall discussed somewhat at length the

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geological features of the channel of the river Irwell, in the neighbourhood of Barton, which he contended did not bear out the views of the author of this paper, and in reference to the fine series of maps which Mr. Roeder exhibited, said he had examined some of them, but in regard to the rivers he had come to the conclusion that they were entirely unreliable. Towns and villages were marked with a vague kind of accuracy, but the details of the country were so confused that it was impossible to base any conclusions upon them.

ON THE ANCIENT CANOE FOUND AT BARTON-UPON-IRWELL.

By Mr. Mark Stirrup, F.G.S.

It has been a matter of surprise to many that the excavations for the Manchester Ship Canal, cut, for the most part, through alluvial strata of an old river valley, have so far yielded very little of archæological interest. This may perhaps be accounted for in some measure, not so much by the actual absence of such small things as coins, stone, and metal implements or other objects of human industry, as by the modern mode of carrying out these large engineering works, where the giant scoops of the steam "navvy" replace the old method of manual labour and the use of the pick and spade; thus greatly reducing the chances of discovery of any antiquarian relics, which would be of great value in determining the age of the various deposits, that are now being opened up to the investigation of the geologist and archæologist.

It was, therefore, with no small amount of interest that the report of the discovery of a so-called "Pre-historic canoe" was recently received, reviving the hopes of finding

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further memorials of past events in our local history, the pages of which are as yet unwritten.

Though the title of "Pre-historic" has been given to this boat, such designation, implying its age, must be received with caution, and in the present stage of enquiry with considerable doubt. *Pre-historic* is an indefinite term, varying in its chronological signification in different countries. In the British isles it may justly be said to be synonymous with *pre-Roman*, while in Southern Europe it would have a more extended value.

My object in offering this paper is to discuss the evidence we have for determining the age of this "Pre-historic canoe," which has been previously described in a short article in the *Manchester Guardian* of 5th April last, and more recently by Mr. Alderman W. H. Bailey before the Manchester Literary and Philosophical Society. (See No. 4, Vol. II., Memoirs and Proceedings of Manchester Literary and Philosophical Society, 1888-9.)

The sources whence information might be expected to be derived as to its probable age are—(1) the characters or internal evidence which the boat itself presents, and furthermore, its comparison with others found under similar circumstances and in like condition; (2) the nature and position of the beds where the canoe was found; and (3) valuable aid in coming to a correct conclusion on these points might be derived from other relics of human workmanship found in the same place or in geologically correspondent strata.

The canoe was discovered on the 2nd of April last, in the "Salt Eye," or "Salteea" cutting of the Ship Canal, near Barton-upon-Irwell. An examination of the figure A (see Plate) will give a fair idea of its general appearance, soon after its discovery. The piece torn out of the side was the work of the steam-navvy during its extrication from the sand, in which it was firmly embedded.

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Its position was some 400 feet distant from the present river channel, and it was found buried in old alluvial deposits of silty sand, some 25 feet below the actual surface.

With it were hazel nuts and fragments of wood and trees' and the lower part of the bed of sand on which it lay is streaked or mixed in places with particles of coaly matter.

It had probably been swamped during some abnormally heavy flood and carried down suddenly, much after the manner of similar incidents during the rainy season in the rivers of tropical climates, such as one mentioned by Dr. Hooker, in his Himalayan Journals, when speaking of the Ganges during the rains, he says, "long islets are heaped up and swept away in a few hours. Boats are caught in whirlpools formed without a moment's warning and sunk, 'ere they have spun round thrice in the eddies."

It is what is known as a single piece canoe (called in America, "dug-outs,") that is, hollowed out of the trunk of a single tree, which in this instance is probably oak, and is black with age.

I am indebted to Mr. Alderman Bailey and the Council of the Manchester Literary and Philosophical Society for the use of the blocks of the four mechanical drawings, which show the canoe both in plan and section (see Figs. 2, 3, and 4). The transverse section (Fig. 1) shows the outside of the boat to be nearly an exact semicircle, slightly flattened at the sides. From a consideration of these drawings, Mr. Bailey says, "the boat bears evidence of some attempt at design. An imaginary line drawn right through the centre from one end to the other, becomes the true centre, that is to say, there is as much boat on one side as the other. I would infer from this, that before the boat was made, it was designed, and that it was not made by what is called rule of thumb."

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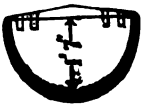

Fig. 1.

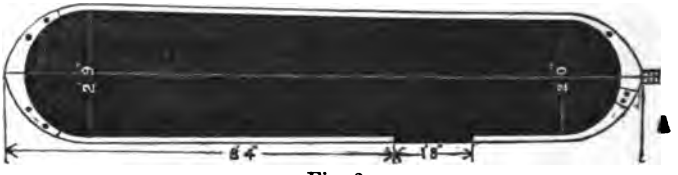

Fig. 2.

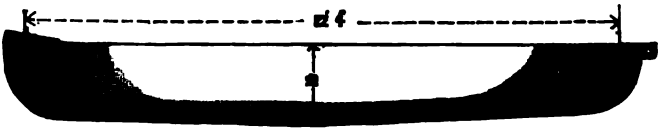

Fig. 3.

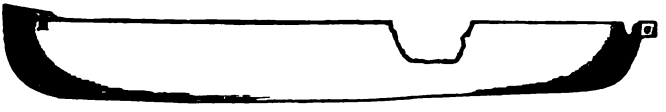

Fig. 4.

The following are Mr. Bailey's measurements :—

Length, outside measure, 13 feet 8 inches.

Length, inside measure, 12 feet 4 inches.

Greatest width, 2 feet 9 inches, gradually decreasing to 2 feet wide at stem end.

The greatest depth is at the centre, where it is 1 foot 7 inches, gradually decreasing to the stern, where it is 17¼ inches deep, and to the stem end where it is 15¼ inches. The thickness of the sides is 1½ inches, gradually increasing to the bottom, where it is 2½ inches.

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The stem and stern are both rounded, the stem end, however, having a short projection, through which a hole about 1¼in. diameter has been horizontally pierced, evidently for mooring purposes.

No row-locks or means of propulsion are visible, the boat probably having been used simply for transport across the river. The bottom is semi-circular in outline, and has no keel. Many of the ancient canoes, which have been found elsewhere, differ in this particular, being flat-bottomed, a distinction which will be referred to hereafter.

There is no trace of iron or any other metal about the boat.

A curious strengthening piece, consisting of a naturally bent branch of a tree may be noticed fixed on to the top of the stern, and this is done with about six rounded wooden pegs, 10 to 12ins. long and 1in. diameter, a similar piece has evidently formed a corresponding office at the opposite end, as may be seen by the holes where the pegs have been.

There are distinct tool marks upon the interior, which are evidently, from their clean cut, those of a metal instrument, probably iron.

Since the canoe has been removed to Owens College, and notwithstanding the care that has been taken to preserve it in something like its original condition, some large longitudinal cracks have made their appearance in the sides.

These have disclosed several other wooden pegs or pins which have been apparently put in to remedy original rents or imperfections.

On the starboard side, near the stern (taking the end having the perforated projection to be the prow), in the space caused by the cracks, may be seen several small round wooden pegs, about ⅛ to ¼ inch diameter, thickening

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towards the head, penetrating the structure, from the inside, in an oblique direction.

These have evidently been the deed of a skilful and ingenious workman, as their presence had previously been undetected.

Two or three larger pegs, similar to those used in fixing on the strengthening piece at the stern, are also visible on the same side, these have no doubt been used to close up incipient cracks, and have probably been inserted from the outside, as no trace could be seen of them from an inspection of the inside of the boat.

Such are the principal characteristics of the Barton canoe, which will be perhaps more readily comprehended by an examination of the photograph exhibited.*

Let us now see whether we can gain any information as to its probable age by a comparison with similar findings in other parts of the country.

The first instance which naturally presents itself, both from its recency and nearness to our district, is the one at Preston in the Ribble valley.

During the late excavations for the new docks and the diversion of the river at Preston, good sections of the alluvial strata have been laid bare, and on the 7th October, 1887, a dug out canoe was discovered, which was soon followed by another, both of which are now in their temporary resting place, at the Cross Street Museum, Preston, waiting their transference to the new Harris Museum.

The first canoe (Fig. B, see Plate) has been described by the Rev. J. Shortt, honorary curator of the Cross Street Museum, in a paper read before the Society of Antiquaries, Feb., 1888, and the second one by Mr. W. H. Heathcote, at a meeting of the Lancashire and Cheshire Antiquarian Society.

Without going into the details of the measurements,

* The Figure A is taken from the photograph.

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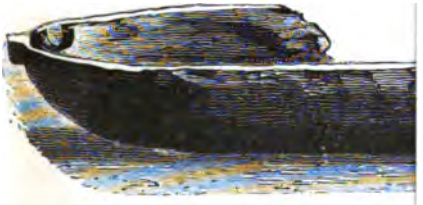

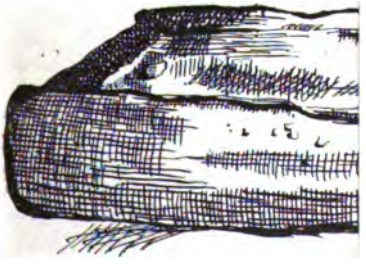

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which are fully given in the papers referred to,* I will only ask your attention to those special points bearing on the question of relative antiquity, and these will be more easily recognised by a scrutiny of the photographs than by any description I can give.†

Both the canoes are like the Barton specimen, single piece canoes, hollowed out of a tree trunk, and were found lying, widely separated, in beds of gravel, 13ft. to 14ft. below the present surface level. Both canoes are much shorter than the Barton one by about 5ft. and 6ft. respectively, and both are of the flat bottomed type. The one first found and described by the Rev. Mr. Shortt has another noticeable feature, the stern, for which the root end of the tree has been used, is an open one, and is closed by a stern board, which fitted into a groove hollowed in the bottom and sides. This groove is placed 7in. from the extreme end of the trunk, thus leaving the exterior part of the tree projecting apparently uselessly behind, unless it served the purpose of steadying the boat. The motive for making these canoes with an open stern and then closing it with a moveable stern board at some little distance from the extreme end, is not at all clear, nor the advantage to be gained thereby very intelligible, as the stern board must have been calked, probably by moss, bark, or other material in order to make the boat

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* Fig. B.—"Extreme length, 8ft. 9in. Greatest width, 2ft. 6in., outside measure at a distance of 5ft. 3in. from the extreme end of the prow. At 2ft. 6in. from the prow it is 2ft. 1in. across, and at 14in. from the prow it is 1ft. 2in. Width at the top of the sternboard inside is 1ft. 7in. The greatest depth within is 1ft. The prow projects 10in. forward of the dug out portion in a sort of nozzle, through which a hole 1¼in. diameter is pierced. The bottom is flat, and at widest part measures 1ft. 8in across. Thickness of the side of the boat varies from 1in. to 1¾in."

† For the illustrations (taken from the photographs) of the Preston canoes, Figs B and C, I have to thank the Rev. Mr. Shortt, who has kindly placed the blocks at my disposal.—M. S.

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watertight, and the fashioning of the grooves must have added largely to the labour, considering the implements that were probably used in the process.

This type, though not the most primitive, is undoubtedly an ancient one, examples of which have been found, under somewhat similar circumstances to those of the Ribble Valley, in both Ireland and Scotland, and more exceptionally on the Continent of Europe.

It is a rare form in Switzerland, but one has been found in the lake of Bienne, and described by M. E. Fellenberg, the separate piece of wood forming the stern-board being fixed inwards about 8 inches from the end.

The presence of this type of canoe in connection with the dwellings of a Celtic people may be of some significance.

The second canoe* (Fig. C, see Plate) described by Mr. Heathcote is an extremely rude one, it is flat bottomed, and is cut off square at the stern end. The stern, however, is not a moveable one, but is a portion of the solid trunk, and instead of forming the extremity of the canoe, is cut a few inches inwards, leaving a small piece of the exterior portion of the tree projecting behind. The bow end is roughly rounded, through which an irregularly shaped hole has been pierced about 2 inches in diameter. There are no signs of rowlocks. The interior has been excavated into a trough like form, and reminds one of the "Einbäume" of the Swiss Lake dwellings of the "Bronze Age" period.

This boat was found encrusted with shingle, and Mr. Heathcote says "shows unmistakeable traces of clear cuts, evidently produced by metallic, probably bronze tools."

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* Fig. C.—"Extreme length, 7ft. 8½in.; greatest width, 2ft. 8in.; width at stern, 2ft. 2in.; depth, 1ft. 2½in.; bottom, 1½in. thick in the centre, and 4½in. thick at the stern. In the bow is an irregularly shaped hole for a rope."

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Both these boats are of a ruder style of art and construction than our Barton one, and might on this ground claim a higher antiquity, citing, for example, the well fashioned stem and stern of the latter when compared with the Preston specimens.

Another reason for considering the Preston canoes more ancient than the Barton one, might be adduced the fact of their association in the river gravels with the remains of the Urus, or the aboriginal wild ox of the British forests, an animal whose remains are comparatively rare, but which apparently existed here in great numbers. Though the size of the skull and horns of the Urus of the Ribble Valley do not betoken so large an animal as that mentioned by Julius Cæsar, as inhabiting the British forests, and as not much inferior to the Elephant in size, yet the specimen mentioned by the Rev. Mr. Shortt, whose horns measure 2ft. 8in. from tip to tip, must have been rather a formidable animal, if only a degenerate descendant of the prehistoric Urus.

Some authorities hold, Professor Owen among the number, that the Urus or Bos primigenius became extinct in Great Britain during prehistoric times, while others hold that it may have survived into historic, in the wilder or less accessible parts of the country.

However this may be, we have unmistakeable evidence of the existence of this wild ox in great numbers in the Ribble Valley, at the time when these ancient canoes were probably used by contemporaneous man for either traversing the stream or for fishing purposes.

Remarkably fine and numerous specimens of the skull and antlers of the red deer, *Cervus elaphus*, have been also obtained from the same deposits, and now adorn the walls of the Preston Museum.

These, perhaps, do not plead for so great an antiquity of these Ribble deposits as the *Bos primigenius*, seeing that the

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red deer still exist in a wild or semi-wild state in the forests of Scotland.

Other rivers and inland waters of the British Isles have yielded from time to time examples of the skill of our ancient boat builders, but perhaps none can compare with the river Clyde and its estuary for the number and importance of its illustrations of these ancient types of naval architecture.

Some 15 to 20 having been exhumed in different portions of the river and estuary during the present century.

The largest of these Clyde canoes was probably one discovered in 1854, at Erskine Ferry, 10 miles below Glasgow.

It was hollowed out of a single oak, and measured 29ft. in length, the stern was an open one, and had grooves for the fixing of a vertical board, like the one found at Preston.

An account of these ancient canoes was compiled by Mr. John Buchanan, and read at the meeting of the British Association at Glasgow in 1855, and therefore I need not further allude to them here, except to mention that an immense antiquity was claimed for them, owing to the position in which some of them were found, viz., beneath the streets of the city of Glasgow itself, while digging the foundations of various buildings, thus showing a great change in the relative level of the land and sea, since the period when they were buried beneath the streets of modern Glasgow.

These Clyde canoes undoubtedly belong to different epochs: while some may rightly claim a great antiquity, others are certainly not pre-historic, as is shown by an examination of the workmanship and the materials used in their construction.

Other examples of these ancient single piece canoes or "dug-outs" have been met with in the inland waters or lakes surrounding the artificial or small natural islands upon

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which the Crannoges or Lake-dwellings of Ireland and Scotland have been constructed.

They are not all of the same type, some being of the trough-like form, while others are pointed at either one or both ends, while others have the moveable stern piece let into a groove, as in the Preston canoe. They are for the most part flat-bottomed.

They differ also in length, from 8 or 9 feet long to 20 or 24 feet, but some are known which far exceed these measurements, showing that trees of almost gigantic size were used for boat-building.

Typical examples of Irish canoes may be seen in the museum of the Royal Irish Academy at Dublin, where the largest known canoe* formed of a single tree, may be seen, whose remains now measure 42 feet in length. The canoe, in its original state, probably measuring about 45 feet long by from four to five feet wide. It was recovered from the bottom of Lough Owel, in Westmeath, and had to be cut into eight pieces for the purposes of transport.

These crannoges, though serving at times the purpose of ordinary rude dwellings, were used also as island fortresses or places of security and retreat by the native kings or chiefs in time of war.

Several examples of these single-piece canoes have been disinterred from the neighbourhood of these crannoges, thus identifying their age with the habitation of these rude structures. The date of the occupation of some of these crannoges is known, as frequent mention is made of them in the Irish Annals, in the battles of the native Irish chiefs, and during the wars with the English, down to the 16th and 17th centuries.

Moreover, Sir Jas. Ware, the eminent Irish antiquary,

* A canoe, measuring 50 feet in length, was found in the Lake of Bienne, Switzerland, but was not brought to the surface.

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who died in the year 1666, says that in his time "dug-outs' were in use on the rivers of Ireland, and it is said of one of the canoes now in the Museum at Dublin, that it bore Queen Elizabeth across one of the Irish streams during her visit to the sister isle.

Similar remarks would apply to the Scotch crannoges, a few of which were in occupation so late as the early part of the 17th century, and some of the canoes found in connection with them, had the peculiar feature, previously described, of the stern, closed by a vertical board sliding into grooves cut out of the solid wood.

While bringing these Irish and Scotch lake dwelling canoes *en évidence*, one cannot help referring to their Swiss prototypes, especially as they are the most ancient of which we have any memorials, and where we are probably brought face to face with the dawn of the art of navigation in that portion of the pre-historic epoch known to archæologists as the polished stone and bronze periods. The lakes of Switzerland have yielded to explorers many examples of this primitive boat, which is nothing more than a trunk of a tree squared on one side, the interior hollowed out into the form of a trough, by the aid of rude stone implements, assisted by fire, probably in the same way as is related of the Indians in America,* the external portion of the tree being left un-

*Beverley, in his History of Virginia, says: "They bring down a great tree by making a small fire round the root, and keeping the flame from running upward, until they burn away so much of the basis, that the least puff of wind throws it down. When it is prostrate they burn it off what length they would have it, and with their stone tomahawks break off all the bark, which, when the sap runs, will easily strip, and at other times also will come off when well warmed by fire. When it is brought to a due length they raise it upon a bed to a convenient height for their working, and then begin by gentle fires to hollow it, and with scrapers rake the trunk, and turn away the fire from one place to another, till they have deepened the belly of it to their desire; thus also they shape the ends till they have made it a fit vessel for crossing the water; and this they call a canoe, one of which I have seen 30ft. long."

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touched, no fashioned bow or stern, but the ends cut square or straight, and no signs of rowlocks, the boat probably having been propelled by a pole or paddle.

Those with the ends pointed or rounded would seem to be an improvement and advance upon this earliest type, yet the flat bottomed canoe, with its trough shaped interior of our British examples, is a very ancient form which resembles closely some of these specimens of prehistoric workmanship. Similar canoes to these ancient dug-outs are said to be still in use in some parts of Eastern Switzerland, and are even still manufactured.

Dr. Keller, in his work on the Lake Dwellings of Switzerland, says that in 1865 he saw a boat of this description in the harbour of the town of Zug. Thus the mere fact of these canoes being made of hollowed trees, does not entitle them to any hoary antiquity, nor can even the rude shape be taken as a sure criterion, for canoes have been found of the most ancient or rudest type, yet containing articles of iron. The internal evidence, therefore, of the Barton canoe and its comparison with those of other districts, found under similar circumstances, lends no support to the assumption of its prehistoric character.

Having roughly indicated the character of the evidence of antiquity to be drawn from a comparison of numerous examples of ancient dug-outs, both at home and abroad, let us now see whether more reliable or exact data as to age can be gathered from an examination of the nature and position of the beds where the canoe was found.

The canoe lay, as you are aware, in the soft and incoherent beds called alluvial, because deposited by the old river in some former period of its history.

We know that these deposits are recent from their

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position, but we have no reliable means of guaging their age from the thickness of the beds, as no measures have been taken to ascertain the quantity of earth, sand and gravel, that may be carried down and deposited by the river in any single year.

The quantity of material transported by a river is moreover not constant at any time of the year, or in any part of its channel, it varies according to the velocity of the current and the volume of water in the channel. In flood time the matter held in suspension is much in excess of that when the water is low and flowing quietly.

Many attempts have been made to utilize as natural chronometers, the growth of river deposits, deltas, peat bogs, &c., but the results at the best can only be approximative, and often are most misleading.

When you have no uniformity or regularity in the amount of matter deposited in any single year, the attempt to value the amount of accumulation of 100 or 1,000 years must be fruitless. Moreover these deposits once formed, are subject to continual changes and removal, owing to the irregular action of the stream, and one abnormal flood may upset the nice calculations of many years.

Although you will see that no reliance can be placed on alluvial deposits as a measure of absolute time, yet they are often of great value as *relative* chronometers.

For instance, close investigation has been made of sections of the alluvial deposits on the banks of such rivers as the Saone and the Rhone; and in a certain order of superposition have been found fragments of Roman pottery, coins, bronze, and stone implements, bones of extinct animals, &c.

By this means you can establish a relative chronology, as

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the layers beneath that containing Roman coins and pottery, must be pre-Roman, and so on.

If we had been able to find similar relics in the beds at Barton, we should have made use of them as a valuable and interesting natural chronometer for assessing the probable age of our canoe, but their absence renders this impracticable.

Thus the third source of information, as I suggested, whence probable aid might be sought for determining the age of the canoe fails us, as no relics to which any definite antiquity can be attached have yet been discovered.

In making this statement, I do not forget the wooden comb which Mr. Roeder exhibited here a short time ago at one of our meetings, but it is an article, though rude and antique in form, which may belong to any age or country, and probably similar examples might be found in use in out-of the way districts even at the present day.*

To sum up our review, we see that no certain data are available for arriving at a correct conclusion as to the absolute age of this so-called pre-historic canoe.

We find, by comparison, that the form is not one of the oldest types, its stem and stern are fairly well modelled and rounded, it has a large internal capacity, and shows higher art, greater skill, and an access to better cutting tools than many of those that have been referred to. Even if it had been of a ruder and older type, that alone would not be a sufficient reason for classing it as pre-historic, for I well remember some 25 or 30 years ago standing one summer

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* A wooden comb very similar in make and form to the one discovered by Mr. Roeder at Barton was found by Dr. Angus Smith, F.R.S., in some excavations made by him at the lake dwellings at Ledaig and Lochnell, Argyleshire, and described in Proc. Soc. Antiq. Scot., Vol. X., p. 82.

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evening on the bridge which spans the Towy at Caermarthen, in South Wales, and seeing a number of fishermen approaching the river banks, from different directions, each carrying his boat upon his back, evidently not a heavy burden, as he moved lightly on his way with his hands free. What kind of boat was this, none other than the old British "carach," or coracle, a fishing canoe similar to those seen in use by the Roman soldiers when they invaded Britain, and of which an account is given in Julius Cæsar's "Commentarii de Bello Gallico."

The coracle is still, I believe, in use on some of the Welsh rivers, and why? possibly because of its lightness, convenience, and fitness for the work it has to do, advantages which have not yet been superseded by the modern and more expensive clinker-built boat.

Here then we have a boat, certainly of a pre-Roman type, coming down to us unimproved from barbarous ages.

If the form or rudeness of workmanship cannot therefore be adduced as a sure criterion of antiquity, we cannot lose sight of the fact, however, in estimating the age of the Barton canoe of its having been found buried deep in alluvial strata, but in the consideration of this portion of the question caution must be used, and it will perhaps not be inappropriate here to quote the observations of Dr. Geikie, when referring to the buried canoes in the valley of the Clyde (*Quart. Jour. Geol. Soc.*, Vol. 18, p. 224):—

"The relative position in the silt from which the canoes were exhumed could help us little in any attempt to ascertain their relative ages, unless they had been found vertically above each other. The varying depths of an estuary, its banks of silt and sand, the set of its currents, and the influence of its tides in scouring out alluvium from some parts

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of its bottom and re-depositing it in others are circumstances which require to be taken into account in all such calculations. Mere coincidence of depth from the present surface of the ground, which is tolerably uniform in level, by no means necessarily proves contemporaneous deposition. Nor would such an inference follow even from the occurrence of the remains in distant parts of the very same stratum."

The same reasoning would apply to the changes continually going on in the banks and beds of rivers by the deposition, removal, and re-deposition further down the channel of the sands and sediments carried by the current.

Great changes are brought about by storm waters or floods, new channels made, old ones closed, and these alterations of the bed are not slow of growth, but probably the result of only a few hours' work.

Therefore, you will infer that alluvial deposits, barren of any relics of man's handiwork, can scarcely avail us in any correct estimate of the age of the canoe in question.

We have seen that man, especially when in a rude state of civilisation, has, in all ages, according to his necessities and opportunities made use of the same raw materials and fashioned them much in the same way in countries widely separated from each other.

Notwithstanding the progress of arts and manufactures, so marked and so visible in the neighbourhood of our congested cities and towns, yet one may still occasionally find the past, as it were, living in the present, and ancient habits and customs holding their sway over isolated people or communities.

To sum up then the whole matter by the evidence at hand, I think the Barton canoe can not rightly claim its title of

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pre-historic, and it would appear by comparison with the two found at Preston to be of more modern construction than they.

The conclusion then would be that it is of post-Roman age, and that its years may be numbered only by a few centuries, but how many it would be impossible to tell.

Mr. KENDALL pointed out that all the boats found at different periods, at Preston, at Glasgow, and elsewhere, needed careful description, little being known about the age of any one of them. He could not endorse all Mr. Stirrup's conclusions. He did not think, himself, that an excavated boat like that found at Barton, could have been fashioned in such very recent times. It was not probable that a people acquainted with the merest elements of joinery would construct a boat by such a laborious process. It was more likely, he thought, that they would split planks roughly and piece them together. He was encouraged in this view because the boat showed no signs of provision for oars or sails. He did not think it likely, judging from the build of the boat, that it could have been a ferry boat. It was such a boat as, even brand new and with all its pristine buoyancy, he would not like to navigate on a stream like the Irwell. He thought for the purposes of a ferry they would be more likely to use a roughly built punt. Comparing this with the Preston boat, he was inclined to think that it represented a ruder type. The Preston boat (the one described by the Rev. Mr. Shortt) was rather delicately shaped; it was flat bottomed, which was the only thing that could be urged against its age, and he was inclined to think that that graceful shaped Preston boat was of much finer workman-

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ship than the one found at Barton, and altogether of a higher type. He believed the loose stern board in the Preston boat served a very important function. One circumstance which induced him to regard the boat of considerable age, was the fact that Leigh in A.D. 1700 described a dug-out found at Martin Mere, and showed conclusively that such boats were not in use in the neighbourhood in his time by the wild speculations he indulged in regarding the nationality of the boat-builders. The boats found at Glasgow were generally of the type with moveable stern boards. They had the advantage, in two cases which might be cited (one of them having a very interesting connection with the Barton boat), the means of fixing the minimum age of these boats. Boats had been found in the Carse of Falkirk and the Carse of Stirling, of which descriptions had been published, and from evidences of the Roman occupation in their immediate vicinity they were enabled to say that those boats were not later than the second century of the Christian era at all events. But he agreed with Mr. Stirrup that it was quite impossible to estimate the age of any of them from the geological surroundings.

Mr. STIRRUP said he could not accept Mr. Kendall's view as to the age of the Preston "Dug-outs" with a moveable stern board. They were, in his judgment, of a decidedly older type than the Barton boat, taking into consideration both the workmanship and the fact of their being flat-bottomed. Nor could he endorse his appreciation of the graceful lines of the Preston boat.

He adhered to the opinion he had expressed from a full consideration of the facts he had put before them. It was somewhat difficult to conceive that a boat whose lines were so true that, as stated by Alderman Bailey, he inferred it

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was designed, from the fact, that an imaginary line, drawn through the centre, from one end to the other, was the actual centre. That would be a singular circumstance if it were what Mr. Kendall described it to be, a roughly dug out boat.

This concluded the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XX. SESSION 1888-9.

SPECIAL MEETING AT WIGAN.

A SPECIAL MEETING of the Members was held on Friday, 2nd August, 1889, in the Mining School, Wigan.

This Meeting was called in accordance with a resolution passed at the last meeting at Wigan, on the 10th of May, when it was resolved to adjourn the discussion "On the Use of Roburite in Coal Mines, and on the Effects of Roburite Fumes," until the publication of the report of a Committee of medical gentlemen (*see Report, page 329*), who had been requested to test the accuracy of the complaint of the men at the Park Lane Collieries, Wigan, as to the injurious effects of the fumes of roburite.

In the unavoidable absence of the President, Mr. HENRY HALL, H.M. Inspector of Mines, was called to the Chair.

The CHAIRMAN said all he had got to do was to ask some gentlemen who had had some experience of roburite to continue the discussion. Roburite seemed to him to have become rather a party question. He thought the Society, at any rate, should try to discuss it, without any reference

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to party at all, but simply upon its merits. Perhaps the best thing he could do would be to ask Dr. Hannah if he had anything to add to the report already issued.

Dr. HANNAH did not know that he had anything further to add to the report. As regarded the fumes of roburite, he and his colleagues, who conducted the inquiry at Park Lane, were in a closed up place, three feet high, for about an hour, and several shots were fired, but personally they experienced no inconvenience themselves, and the chemical analysis of roburite showed that there was no noxious gas from the material itself. The investigation was a very thorough one, and lasted some three months, and he thought that every little detail in connection with it was carried out. The inquiry was entirely confined to the question of roburite fumes. There was no issue put forth as to make any comparison between that explosive and any other—gunpowder, for instance. With respect to the information obtained, he wrote to all the different employers in the district who had used roburite, and all the evidence he got from them was quite satisfactory. There had been a case at one or two collieries of ill effects, but it was directly traced to wrong manipulation of the cartridges. So far as his own experience went, he had no case of poisoning from the fumes of roburite. He saw that the question had been raised that roburite must be detrimental to health, for the reason that vermin had been killed in the pit where it was used. That was all very well, but it was a very strange thing, if it did affect the men's health, they did not see cases turning up which could be absolutely attributed to it. If it was harmful, the horses and ponies in the pit would be poisoned, for just the same oxidization went on in them. He was satisfied in his own mind that the fumes evolved from roburite were innoxious.

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The CHAIRMAN: There was one point which seemed to be of importance. Have you made any experiments of the effects of the fumes of gunpowder?

Dr. HANNAH said they did not make any analytical test with regard to gunpowder—they simply saw the fumes of that explosive more out of curiosity than anything else.

The CHAIRMAN: You simply fired the shot?

Dr. HANNAH: Yes, and went into it to see what it was like.

The CHAIRMAN: Which do you think would be more likely to be most injurious, gunpowder or roburite?

Dr. HANNAH: Gunpowder. I would sooner work in the roburite fumes than in those of gunpowder.

The CHAIRMAN asked if some gentlemen who had used roburite since the last meeting would give his experience.

Mr. CLARK said: With regard to using roburite, that the matter had been settled at the Park Lane collieries, as at the latter end of January the men there agreed to use it in most of the mines, and he had not had a case brought to his knowledge of any man being affected by the fumes or from the handling of the roburite. Many of the old colliers told him they preferred the fumes of roburite to those of gunpowder. He asked Dr. Hannah if he knew what the component parts of the fumes of gunpowder consisted of. They were told in the report that "when the roburite was fired in the boiler without being confined in coal, we could detect no carbonic oxide in the products of the explosion." It appears from this that the carbonic oxide is produced by the action of the heated gases of the coal, and is not a direct product of the explosion of roburite. We think it probable that all explosives giving off carbonic acid would produce

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traces of carbonic oxide due to the contact of heated carbonic acid with coal." If they knew what the component parts of the fumes of gunpowder were, he thought it would be a matter which perhaps might go a long way to settle that question, which seemed to be agitating the minds of some portion of the mining community in the district. He did not know whether the colliers themselves were complaining much about it. If they had information to prove the comparative component parts of gunpowder and roburite, and other explosives it might settle the minds of those people who were hesitating about the matter. The question of explosives was a most important one, and was brought about by the legislation of 1887, when the Mines Regulation Act was passed. Practical mining engineers knew that the way in which it was stated gunpowder should be used was simply impracticable, and therefore they had to look round to see what explosive they could find that would comply with the regulations laid down in the Act, and the introduction of roburite came about. It was tested most carefully, not by the Roburite Company themselves, but by practical mining engineers in the district, and in France and Germany, who satisfied themselves that under most ordinary circumstances it was an explosive that could be used to carry out all the requirements of the Act of Parliament. Roburite was not a thing they jumped at without fully ascertaining that there was something in it, and he thought the public generally would give the mining engineers and colliery proprietors credit for this, that if they had the slightest idea that the fumes of roburite in any way whatever interfered with the health of the workmen, they would be the very first to seek its withdrawal from the pits. However, from inquiries he had made at neighbouring collieries where roburite had been used, he had not been able to ascertain one authenticated case of a workman being affected by the

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fumes. There had been some cases of injury or poisoning from the manner in which it had been handled.

The CHAIRMAN: Not any fatal poisoning?

Mr. CLARK: No, and I think if roburite is deleterious or does effect the health of the workmen it would have been seen before now, because there are all kinds of constitutions amongst the colliers, and if the fumes are of that harmful character they are stated to be they would have had some effect on delicate men.

Dr. HANNAH said the point about explosives producing carbonic oxide was a purely scientific one, and was referable to the amount of heat generated by the explosive. Some explosives were very much higher and generated more heat than others, and he thought gunpowder was one of the lower forms, giving less heat. It was a chemical and scientific question altogether, and he could not answer it, but he believed that some carbonic oxide was given off directly from gunpowder—a small quantity—and many other gases, sulphurous acid and others, which were very irritating to the respiratory tract.

Mr. SAINT asked if any of the members had experience of the use of roburite where a blown-out shot had been produced and whether any flame had been noticed.

The CHAIRMAN: And producing flame?

Mr. SAINT: A blown-out shot producing flame.

Mr. CLARK said he had not heard of a blown-out shot taking place at the Park Lane Collieries, and he could not answer the question.

Mr. SAINT thought perhaps in the recent experiments a

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hole might have been charged for the purpose of producing a blown-out shot.

Mr. CLARK: That might have been done, but I am not aware of it.

The CHAIRMAN: All the tests that were made some time ago were what we call blown-out shots. They were fired out of a cannon, so that they might blow the ramming.

Mr. SAINT: Yes, but I mean blown-out shot in the solid coal.

The CHAIRMAN: They were somewhat similar.

Mr. SAINT: You have no coal dust.

The CHAIRMAN: No, but we watched for a flame coming out of the mouth of the cannon. Have you heard that flame has been seen?

Mr. SAINT: Yes.

The CHAIRMAN: You might give us more details, because it is very important.

Mr. SAINT: I have had no experience of it, but I can give you the name of the colliery. It was at the Bedford Colliery, where two or three shots were fired to test it. In two of them flame was seen—in one more distinctly than the other.

The CHAIRMAN: We want the unfavourable as well as the favourable in a matter of this kind.

Mr. SAINT: It seemed to me to be rather an important point, because there have been explosions recently which have been attributed to blown-out shots of gunpowder.

Mr. BOOTHE said the case mentioned by Mr. J. L. Hedley at the last meeting seemed to be one in point of a blown-out shot not producing any flame.

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Mr. SAINT: I don't think that was equivalent to a blown-out shot.

Mr. BOOTHE said if a blown-out shot of roburite created flame he did not see where the advantage of the new explosive was. He thought the men were opposed to roburite on account of the fumes, and if they set themselves against the men, while at the same time roburite was not so safe as it was said to be, it seemed to him they would be giving themselves unnecessary trouble.

The CHAIRMAN: Is there anyone here who has had a blown-out shot during the last two or three months?

Mr. COCKSON said they had had one at their colliery (Ince Hall), but not in coal. It was in some very hard rock. The shot undoubtedly blew out, but the man told him there was no appearance of flame whatever. He thought the point raised by Mr. Saint about blown-out shots was amply answered by experiments at the Wigan Coal and Iron Company's works, where repeatedly blown-out shots had been fired into a fiery mixture—in some cases with a stemming of coal dust—and the gas was not fired. In addition to that, he understood that in the experiments which were made in Germany and Yorkshire, tests were made with blown-out shots in a mixture of coal dust and gas, and no explosion resulted, so that whatever the appearance of the flame may have been which was seen at the Bedford colliery they could safely say that it would not inflame gas. Whatever was seen was nothing more than a reflection or appearance of flame, and could do no mischief. With regard to the composition of gas caused by an explosion of powder, he had some information which he had obtained from a chemical book called "Watt's Dictionary of Chemistry." He found from the analysis worked out by Professor Abel that after testing several varieties of powder

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the proportion of carbonic oxide varied from 7·9 up to 14·7 per cent. In a note at the end of the analysis it was stated that the "explosion was made in an iron vessel or pan." And it was stated that the manner of exploding the shots and the difference in the pressure might materially alter the composition of the gas. This, together with the varying qualities of powder used, accounted for the difference in carbonic oxide in the analyses, the difference being from 7·9 to 14·7 per cent. He had no idea that the amount of carbonic oxide caused by an explosion of powder was anything so great as that, but he had no reason to doubt the accuracy of the figures he had quoted. He thought the only construction they could put upon the thin attendance of members was that there was nothing to discuss on the medical report. They all admired the fairness with which it had been framed, and it seemed to him the conclusions at the end of it were so perfectly clear and distinct as to the safety of roburite, where anything like precaution was taken, that people thought it unnecessary to discuss the question further. If one read the general conclusion at the foot of the report, in which the experts say, "Our general conclusion is that although roburite itself is a strong poison, and, undoubtedly, cases of poisoning have arisen from it, yet if stringent care is exercised . . . . the use of roburite will not add to the harmful conditions under which the miner works," they would have the sum and substance of the report. He took it that in all collieries that precaution was taken, and consequently he thought they might say that they had in roburite a safe explosive, if they used the precautions named by the Roburite Company. He for one had not the least hesitation in continuing the use of roburite and in feeling fully satisfied that it was an absolutely safe explosive, and that with anything like reasonable

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care there was no danger to the health of the shot-lighters or the men. He thought if the terms of reference with regard to the inquiry at Park Lane had been wider, so as to allow Dr. Hannah and the other experts to make experiments on the result of gunpowder and other explosives, as well as roburite, it would perhaps have been preferable, as now they had no information with regard to the former. He thought the men need not be alarmed at any reports that had been circulated about roburite. It seemed to him that their interests were perfectly protected by the Mines Regulation Act, a section of which stated clearly that if anything was done at a colliery which tended to the bodily injury of any person employed, the inspector of the district had full power to have it altered. If the employer did not stop it the inspector could compel arbitration and the result would be that if anything was found which was wrong or might be harmful, it would be stopped. He thought that with the powers given to the inspectors of mines the men might feel assured that nothing could be done that would prejudice their health or interests. He fully expected that before many months were over they would feel surprised that so much had been said—or that anything had been said adverse to the use of roburite. He felt sure that in six months time they would be very much at one on that question, and instead of hearing of roburite being used by a certain proportion of the collieries in the country it would become very much more generally used and that the men would agree with his opinion as to its being thoroughly safe and harmless.

The CHAIRMAN thought that though they were there only to discuss the effects of roburite fumes, yet they might widen the inquiry to include the point to which Mr. Saint had referred. They had pretty well threshed out the question of fumes—that point had been settled, but it was a much

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more important question which Mr. Saint had raised as to whether there was flame in blown-out shots. If there was anything in what Mr. Saint had said, he thought the inquiry was only beginning and not ending. They might ask Mr. Bigg-Wither if he had any information as to what the effect would be when shots were blown out.

Mr. Bigg-Wither, General Manager Roburite Explosives Company, Limited, said the only points he could refer to were the experiments with blown-out shots at the Wigan Coal and Iron Co.'s works. The Roburite Company had intended to make the experiments, but when they heard they were going to be made by practical persons far better able to judge impartially, they decided to leave the matter entirely to private hands. The results of those experiments were to him entirely satisfactory and proved everything he knew of roburite. In no instance where a blown-out shot was so made by charging a cannon with Roburite and with only a small quantity of tamping, was the inflammable mixture ignited—the only instance in which it was ignited was when there was no tamping at all. Mr. Bigg-Wither then read the instructions issued by the company for using the roburite, and, proceeding, he said that out of the twenty-one experiments at the Wigan Coal and Iron Co.'s works, seven shots of roburite were fired into the gas and not a single one ignited it. He understood that the tamping of an explosive with coal dust, especially dry coal dust, rendered it more liable to cause flame than anything else, but the result of the explosions under these conditions even gave equally satisfactory results. As far as the company were concerned they stood by those experiments. He then stated the quantity of roburite the Wigan Coal and Iron Company, Messrs. Evans and Company, Messrs. Cross Tetley and Company, the Garswood Coal and Iron

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Company, and other firms had used, and said that the explosive was used not only in this district and others, but in Durham, where the mines were very fiery, and he had not had a single complaint from that county. Some experiments were carried out in Durham two years ago which satisfied those present, and since then the parties who conducted the experiments had been using the explosive in the mines under their charge. He believed that everything claimed for roburite had been fully maintained, but there were drawbacks (there were mis-shots) with every explosive. He believed that powder when brought in contact with coal dust produced carbonic oxide to a larger extent than Roburite under the same conditions. The medical report on the combustion of roburite proved that roburite when exploded by itself gave off no carbonic oxide. The fumes and poisonous nature of the article during manufacture had been mixed up with the fumes of combustion, and those two points were very different.

Mr. MERCIER said what little roburite he had used had blown coal very much better than gunpowder, and no light had been seen.

Mr. GRUNDY thought there were many parts of the medical report to which attention might well be called, both as to the roburite itself, and the fumes. He was much pleased to see the tone now adopted with respect to roburite, namely, of using it very carefully, if not a little suspiciously. They ought to be careful that it was cautiously handled and not brought into contact with the skin, and that the men should not go into the fumes. It would be very wrong if men got the idea either that the substance itself or the fumes were harmless. He might mention one or two cases that came under his notice the other day with respect to handling the explosive. A statement was made in the report of the experts

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that the men need not handle the explosive. The other day a shot firer took a cartridge to put in a detonator and he found a lot of roburite between the folds, part of which came upon his hand. Again, a stick used to make the hole in the roburite for the detonator was for over four inches covered with wet roburite, and for four inches with dry roburite; there were eight inches of stick quite ready to convey roburite to the hand. Another way in which roburite got on the hand was when one of the two or three cartridges put in a shot-hole missed fire, and to get the unexploded roburite out of the hole it was felt necessary to handle it. The men assured him they felt very little from the effects of roburite, but they felt it most when inserting the detonators, when they had pains in the head and each side of the temple. One or two of the men said although they did not feel bad, they noticed they had gone very much paler in the face.

The CHAIRMAN: Were they colliers or regular shot-lighters?

Mr. GRUNDY: They were tunnellers.

The CHAIRMAN: Then it was the chargemen who complained?

Mr. GRUNDY said, in the report of the experts it was stated that the smell of roburite was the smell of nitro-benzine, and that the toxic properties of these compounds increase with the number of nitro groups attached to the benzine. It had, perhaps, been noticed that one of the substances from which roburite is made was di-nitro-benzine. The creamy substance noticed in the fumes might turn out to be of more importance than at first sight appeared. Perhaps the effects on the men might be due to those unknown substances. If a roburite shot was charged with an insufficient quantity of roburite to blow the coal or rock down, very likely fine particles

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might linger behind the coal or stone, and when the collier went to get it down they were there to face him. He made those remarks, not that he was anxious to say anything against roburite, but rather to get people to use it carefully. Let them be careful that the men did not handle it any more than was absolutely necessary, and that when a shot was fired, the place was cleared of fumes before the men were allowed to enter.

The CHAIRMAN said it seemed to him some of them were losing sight of the great fact that if they could get an explosive which would not give off flame, the amount of life saved would be very much greater and out of all proportion to any ill effects that could arise from any mis-manufacture of the explosive that it caused fumes that might be harmful to some extent. Those were all very small matters. If roburite served the purpose of an explosive that did not give off flame, they should not pick and quarrel at little things about it. What they wanted to satisfy themselves about it was whether it did or did not give off flame. If it did not then they would all accept it gladly, both miners, owners, and everybody connected with the coal trade.

Mr. GRUNDY said his remarks were intended to show that everyone using it was in duty bound to find out what the qualities of roburite were, both with respect to flame and to poison entering the substance.

The CHAIRMAN: Is it the wish of the meeting that this discussion should be adjourned or closed? My own opinion is that something more might be said, and it would be well to adjourn it. I think it is the most important matter that has been before the coal trade for a long time.

Mr. CHANDLEY asked if the miners' conference had some special information about roburite which had led them to take the step they had.

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The question was not answered.

Mr. CLARK thought they had better close the discussion, and if there was any further light to throw upon the use of roburite it could be brought before some other meeting. Some of them would take the opportunity of comparing blown-out shots, and see whether any flame issued from them or not.

Mr. SAINT: I think it is a question which might be easily demonstrated.

On the motion of Mr. CLARK, seconded by Mr. SAINT, the discussion closed.

Mr. COCKSON, in proposing a vote of thanks to Mr. Hall for presiding, said if the members of the Society would like the safety of roburite demonstrated, he was sure the Roburite Company, when they had erected their testing house, would be happy to arrange a series of experiments with gas or coal dust to be carried out by a Committee of the Society.

Mr. CLARK, in seconding the motion, thought it would be very much better if people who took an interest in the matter would have experiments made by themselves in the mine. He should take that course and report to the Society.

The motion was passed and the meeting terminated.

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APPENDIX.

REPORT OF THE COMMITTEE APPOINTED TO ENQUIRE INTO THE EFFECTS OF ROBURITE FUMES ON THE HEALTH OF THE WORKMEN.

(Published in the "Wigan Observer," May 25th, 1889.)

Appointment of the Committee and Reference.

At a Conference held on January 22nd, 1889, at the offices of the Park Lane Colliery, between the representatives of the Garswood Coal and Iron Company, and a deputation of the Lancashire Miners' Federation, it was agreed that two medical practitioners should be appointed, one by each party, and that these two medical men should appoint a chemist to act with them in an investigation into the effects of the explosive, Roburite, on the health of the workmen in the Park Lane Colliery. In accordance with this agreement, Dr. N. Hannah, of Ashton-in-Makerfield, was appointed by the Company, and Dr. C. J. Mouncey, of Earlstown, was appointed by the Miners' Federation. Messrs. Hannah and Mouncey agreed to ask Mr. H. B. Dixon, F.R.S., Professor of Chemistry in the Owens College, to act with them as scientific assessor in the inquiry.

Scope of the Inquiry.

We, the Committee of Inquiry so formed, accordingly proceeded to investigate the chemical nature of the explosive, and the method of its manufacture into cartridges, and we specially tested the products of explosion of Roburite, both under the ordinary conditions of working in coal mines, and

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also under special conditions, viz., in mines without ventilation, and in closed vessels.

Every facility for observing the process of manufacture, and for testing the ingredients of the explosive, was shown us by the Roburite Company at their Gathurst works. The Committee made frequent visits to one or other of the pits at the Park Lane Colliery. We had many opportunities of closely watching the manipulation of the cartridges, and we were able to test the atmosphere immediately after shots had been fired, both in the return air-ways and at the working faces, when the ventilation had been entirely cut off.

The Committee have also examined shot firers and workmen who have either handled the cartridges, or been exposed to the fumes of the explosive.

In forming our conclusions, we have been guided not only by the experiments made at the Park Lane Colliery, but also by observations we have made at other collieries where Roburite is used.

Nature of Roburite, and its Manufacture into Cartridges.

The explosive Roburite is an intimate mixture of—

1. Di-nitro-benzine.
2. Chloro-nitro-benzine.
3. Ammonium nitrate.

The di-nitro-benzine is purchased by the Roburite Company in crystals. These crystals (meta-di-nitro-benzine) contain a little nitro-benzine, from which liquid they are crystallized.

The chloro-nitro-benzine is manufactured by the Company by the long-continued action of chlorine on nitro-benzine in presence of perchloride of antimony. The chloro-nitro-

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benzine is then melted with di-nitro-benzine in suitable proportions, while a current of chlorine is driven through the liquid mass.

Finally, the nitrated and chlorinated mixture is melted and run into well ground and warmed ammonium nitrate, and the whole is intimately mixed together and allowed to cool. The mixture thus prepared is a buff coloured powder, giving off the smell of nitro-benzine. The cartridges are made by packing the powdered mixture into cylindrical paper cases, folding the paper over the ends and dipping the closed cartridges into melted wax to keep them air-tight.

To fire the cartridges, one end is opened by unfolding the paper, the powder is loosened, and a detonator is inserted into it; the paper is then tied round the fuse or wires from the detonator. A powerful detonator holding about one gramme of fulminate is required to fire the mixture. It is the object of the Roburite Company to prepare an explosive which shall, while bringing down the coal in suitable lumps, give out no flame which might ignite coal dust or inflammable gas in the mine. When a roburite cartridge is fired in the open, or when loosely covered over, a flash is seen, but when the cartridge is firmly packed round before firing, no flame or flash is visible.

The poisonous nature of the nitro derivatives of benzine is well known. The toxic properties of these compounds increase with the number of nitro groups attached to the benzine. But as the singly nitrated nitro-benzine is more volatile than the more highly nitrated compounds, the danger attending the use of these bodies depends a great deal on the mode of manipulation adopted.

The poison can be inhaled in the form of vapour or fine particles, or may be absorbed by contact with the skin.

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In examining into the effects of roburite on the health of the workmen, we had to consider :—

1. Is the manipulation of the cartridges previous to firing such as to expose the workmen to the action of the poisonous ingredients of Roburite ?

2. Is any portion of the explosive incompletely burnt, giving rise to fumes of nitro-benzine derivatives in the mine ?

3. Is any deleterious gas, such as nitric-oxide or carbonic-oxide formed in the explosion ? And lastly,

4. Are the symptoms complained of by the men such as would be accounted for by one or more of the above causes ?

Manipulation of the Cartridges.

1. The cartridges, as we have described, are soaked in wax, and are thus made air-tight. No smell of nitro-benzine can be detected until the cases are opened.

At the Park Lane Colliery the cartridges are always fixed and fired by special shot-firers, whose duty it is to go round to the working faces in turn. The shot-firer opens one end of the cartridge, loosens the roburite by rolling the case between his fingers, and, after inserting the detonator, ties up the case with string, or folds the paper back over the detonator. He then pushes the cartridge to the bottom of the drill-hole, which he fills in loosely for a few inches above the cartridge, and tightly rams the remainder with "warrant" or clay. The shot is then fired by the fuse or the electric current, and the shot-firer immediately returns to the face to observe the effects of the shot. We have seen the operation of attaching the detonator to the cartridge performed many times in the Park Lane pits, and we can confidently say that there is no difficulty in conducting the operation, and that with care the roburite need neither

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be spilt nor come into contact with the hands of the operator. But while we have seen that at the Park Lane Colliery due care is taken in handling the cartridges, we know, from our own observations, that in some other mines proper precautions are not observed. We refer to instances in which the roburite has been actually fingered by the miners, and to instances in which the roburite has been spilt in the mine in the vicinity of a working place.

Opinion.

We are inclined to attribute the cases of undoubted nitrobenzine poisoning which have been brought to our notice to such improper manipulation of the cartridges.

Incomplete Combustion of Roburite.

2. The gaseous products of the explosion mixed with a cloud of finely divided particles, form the "fumes," which are readily recognised by their smell. These fumes diffuse into the air and pass away from the coal face with the ventilating current. Where the ventilation is good and the current of air is brought near to the face the fumes disappear in a few minutes. When, however, the coal is not brought down by the explosion, but deep fissures are made in the seam, the fumes linger in the cracks until the miner brings down the coal with his pick. To examine the fumes at the working faces it was necessary to stop the ventilation. The current of air being short circuited, the fumes could only escape by a slow process of diffusion from the heading. Sitting in the trapped fumes arising from the explosion of two cartridges, we drew the atmosphere through filters of spun glass to collect the floating particles of cloud. In most of our experiments two four-ounce cartridges were fired, and ten cubic feet of air were drawn through the filter. On examining the filter there was found a deposit, which consisted mainly of finely divided coal, but contained

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also a small quantity of another substance. This substance could be separated from the coal by solution in pure ether. On evaporating off the ether the substance was obtained in the form of a yellow fatty solid. This substance was examined carefully for nitro-benzine and di-nitro benzine; but although the chemical tests for these bodies is delicate and easy of application, no trace of them could be discovered. With the object of obtaining more of this solid, many experiments were made in a closed vessel under conditions which fairly reproduced those of the coal mine. The cartridges were packed with coal dust in leaden tubes, and fired in the middle of an iron boiler about 30ft. long and 5ft. 6in. in diameter. After several cartridges had been fired in succession, the air from the boiler was pumped through the spun glass filter, or through a solvent. A yellow deposit was obtained similar to that filtered from the fumes of the mine. The substance was not obtained in sufficient quantity to enable a quantitative analysis to be made of it, but qualitative tests showed that it contained no nitrogen, and that it was of a fatty nature. Whether this substance comes from the coal dust alone, which we found yielded a brown extract with ether, or whether it is a mixture of substances coming partly from the coal dust, and partly from the wax and paper of the cartridges, we have not yet determined. We were satisfied in proving that the fumes contained no particles of unburnt nitro-benzine compounds. To these statements one important exception must be made. On April 2nd, the filter was placed in the return airway in the 7 feet Ince mine, and the air was sent through it for an hour, during which the fumes from four shots passed by with the ventilating current. The smell of the nitro-benzine was detected in the fumes from one of the shots, and the chemical examination of the filter showed that a trace of

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nitro-benzine had been caught. This instance of incomplete combustion, although at variance with all our other experiments, occurred in the ordinary working of the mine, and therefore cannot be attributable to exceptional circumstances.

Now, when the cartridges were fixed in the boiler without being confined, we found that incomplete combustion always resulted. Some of the explosive was thrown about the boiler, and fine particles remained floating in suspension in the air. The small nitro-benzine was instantly recognised, and the filter separated a deposit which gave the characteristic tests of that body. It follows from these experiments that the proper tamping of the cartridge, and the right adjustment of the quantity of the explosive to the work it has to do, are matters of great importance in the mine, for it is evident that if the explosive is not sufficiently confined, part of it may be scattered in the explosion without being burnt. We wish to lay stress on this point, for we have noticed considerable differences in the amount of tamping used by different shot-firers.

In the Park Lane Colliery the shot-firers are the only men who handle the cartridges, and they are the first to enter the fumes after the explosion. It was natural, therefore, to look among the shot-firers for symptoms of nitro-benzine poisoning. We accordingly selected for examination one of the shot-firers, who had been firing from 30 to 35 shots a week for the last six or eight months, but we could detect in him no symptoms of nitro-benzine poisoning.

Opinion.

From our experiments we conclude that roburite, when properly confined, undergoes complete combustion, leaving no trace of nitro-benzine derivatives unburnt, but that there is a chance of incomplete combustion occurring owing to the explosive not meeting with sufficient resistance.

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3. From the composition of the explosive, it seemed possible that two deleterious gases—nitric-oxide and carbonic oxide—might be found among the products of the explosion. In order that these gases, if formed, might be detected with greater certainty, experiments were made in the boiler. The cartridges were packed round with coal-dust in strong leaden tubes, or were inserted in a hole in large lumps of coal and tamped with clay. After the explosion the air was filtered by being drawn slowly through spun glass, and was then tested with a solution of potassium, iodide, and starch. No iodine was liberated, showing the absence of nitric-peroxide in the air. Nitric-oxide, if formed in the explosion, would have united with the oxygen of the air to form the peroxide. The tests consequently show that no nitric-oxide is formed, and they also show that no free chlorine is left after the explosion.

No such easy and delicate test for traces of carbonic oxide is known. We had recourse to the colour re-actions of carbonic oxide with palladium chloride, and to the formation and detection of carbonic oxide hæmoglobin in blood submitted to the action of the air. When a piece of white blotting paper is soaked in a solution of palladium chloride and immersed in an atmosphere containing carbonic oxide the yellow colour of the paper reddens, and grows dark red, and finally black when sufficient carbonic oxide is present. In an atmosphere containing but a small quantity of carbonic oxide some time elapses before the red colour becomes marked. The palladium paper was roughly standardized by immersing it in a large gas-holder in air containing one-thousandth part its volume of carbonic oxide, and observing the time required for colouration to reach a certain red tint. After 18oz. of roburite had been fired in

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the boiler, paper freshly soaked in the palladium chloride was introduced. After half an hour the colour was distinctly red. This test cannot be described as a quantitative one. We take it as indicating that the atmosphere contained less than 10 parts but more than one part of carbonic oxide in 10,000. As a further test for carbonic oxide in the boiler, the air was filtered through spun glass, well washed with caustic potash, and then drawn through a dilute solution of de-fibrinated blood. The blood was afterwards examined by the spectroscope side by side with a sample of the same blood equally diluted, but free from carbonic oxide. We have satisfied ourselves by careful examination of the blood submitted to the action of the air from the boiler that roburite fired in coal dust gives off a recognisable quantity of carbonic oxide. The same test with blood was applied in the mine. When the ventilation was stopped, and when two or three cubic feet of air were drawn from near the working face and pumped through the blood, carbonic oxide hæmoglobin could just be detected. A similar test made in the return airway under the ordinary conditions of working gave no indication of carbonic oxide. The gas was doubtless present, but too diluted with air to give the re-action with blood. We could obtain no colour changes with palladium chloride in the mine. When the roburite was fired in the boiler without being confined in coal, we could detect no carbonic oxide in the products of the explosive. It appears from this that the carbonic oxide is produced by the action of the heated gases on the coal, and is not a direct product of the explosion of roburite.

Opinion.

We think it probable that all explosives giving off carbonic acid would produce traces of carbonic oxide, due to the contact of a heated carbonic acid with coal.

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Symptoms complained of by the Miners.

4. In considering the symptoms complained of by the workmen, we have divided the cases into two groups. In the first group we place the symptoms of those men who have been handling and firing roburite cartridges, symptoms which may be attributable to the ingestion on inhalation of roburite; in the second group we place the symptoms of those who have not handled the roburite, but have been working in places through which the fumes of the shots pass with the current of air going to the up-cast.

A. Of those in the first-class which have been brought under our notice, none have occurred in the Park Lane Colliery. These cases may be divided into (1) acute, and (2) those who are more chronic. 1. In the acute cases, within a short time after the poison has entered the system, the patient feels pain in the head and over the stomach. On exertion he finds he has a difficulty in breathing, or may experience a feeling of faintness, and there is great loss of muscular power. The headache, pains over the stomach, and muscular weakness increase until, in severe cases, the patient is almost moribund. The colour of the lips and finger nails is found to be of a violet blue, and the urine passed is very dark coloured. As the poison is gradually eliminated the patient returns to health, but the violet blue colour remains for a longer or shorter period, according to the amount of poison taken up.

II. In the chronic cases the headache is very marked, there is a great drowsiness, the violet blue colour is more or less distinct, intense anæmia, or thinness of blood, is shown by various symptoms, and there are signs of great nerve prostration. The recovery is slow. These symptoms are well known as characteristic of nitro-benzine poisoning.

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B. The cases in the second-class are all characterised by head symptoms, the commonest being headache, usually frontal, and described as a feeling of weight or of a tight hand across the forehead, occasionally occipital and then generally throbbing in character. Sometimes the pains spread to the shoulder, and the constricting feeling across the forehead extends all round the cranium. In most cases there is a complaint of loss of muscular power in the upper limbs, and a more or less constant feeling of drowsiness. Where no headache is spoken of, vertigo or giddiness is often experienced, occasionally followed by vomiting. These symptoms continue as long as the patient remains in the poisonous atmosphere, but abate with varying rapidity on emerging into fresh air. Sometimes the symptoms persist for several days, but usually cease in a few hours, or after a night's rest. These symptoms may be attributed to carbonic oxide poisoning, when small quantities of the gas diluted with air have been inhaled. The quantity of carbonic oxide which will produce symptoms will vary both with the individual and with the state of health of the individual. If the state of the lungs be that of robust health, more carbonic oxide can be inhaled with impunity than if the lungs are in any way affected. In the former case the poison is eliminated from the blood by the oxygen inhaled, in the latter the carbonic oxide accumulates.

Opinion.

We are of opinion that the carbonic oxide produced by the explosion of roburite in coal may be the cause of the headache complained of, especially in those men who are in such a state of health as to be more than usually susceptible to the effect of the poison.

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General Conclusions and Recommendations.

Our general conclusion is that although roburite itself is a strong poison, and undoubted cases of poisoning have arisen from the use of it in coal mines, yet if stringent care is exercised on the part of the managers, shot-firers, and colliers, the use of roburite will not add to the harmful conditions under which the miner works. As indicating the directions in which additional precautions are in our opinion most necessary, we venture to add the following recommendations to our report:—

1. That the entire manipulation of the cartridges should be entrusted to special shot-firers, who should be instructed in their use.

2. That the effective tamping of the cartridges should be insisted on. Experiments would show by what means the complete combustion of the roburite could be invariably secured.

3. That every care should be taken to ensure the removal of the fumes from the working faces before the return of the miners, *e.g.*, by continually bringing the brattice cloths up to the working faces.

4. That the products of explosion should be rapidly mixed with a large volume of air. We lay stress on the necessity for the carbonic oxide being diluted with a large quantity of air before it can be breathed with impunity by those who enter the mine.

Harold B. Dixon,
Chas. J. Mouncey,
Nathan Hannah.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XX. SESSION 1889-90.

The ANNUAL MEETING of the Members was held on Tuesday, the 8th October, 1889, in the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

Mr. JOHN KNOWLES, M.Inst.C.E., J.P., the retiring President, occupied the Chair.

The Chairman called upon the Honorary Secretary, Mr. MARK STIRRUP, to read the Annual Report:—

REPORT OF THE COUNCIL

FOR SESSION 1888-9.

The Council, in presenting the Fifty-first Annual Report of the proceedings of the Society, can congratulate the members upon the close of a Session marked by the continued evidence of a sound vitality and prosperity; the test of which is verified by the numerous and important subjects brought before the meetings for discussion, and by the examination of the Treasurer's Statement.

The following changes in the list of members may be noted: One ordinary member (Lees Knowles, Esq., M.P.,) has compounded for the annual payments and become a life-member, and 14 new ordinary members have been elected and added to the roll.

The losses may be enumerated as follow: Three members have died, two of which, viz., Charles Hardwick and James Radcliffe, your Council have to regret as old and valuable colleagues.

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Five members have resigned, and six have been removed from the list for non-payment of the subscriptions; the net result being that the total number of members is the same as at the corresponding period of last year, although the Society is now undoubtedly in a stronger position, owing to the elimination of the defaulting members.

The list of members is at present thus constituted:—Honorary members 16, Life members 9, Ordinary members 188, making a total of 213.

In addition to the ordinary meetings fixed at the commencement of the Session, two additional ones were held during the year; one at Wigan, for the further discussion of the new explosive "Roburite," and the other an evening meeting at the usual meeting room in George Street, the latter, necessitated by the accumulation of papers in the hands of the Honorary Secretaries, which it was desirable to communicate to the members before the close of the Session.

The papers and short communications (a list of which is appended to this Report) have been both interesting and valuable, embracing, as they do, the various subjects connected with the special objects for which the Society was founded, namely, "The investigation of the mineral structure and organic remains of the earth; and the study of the statistics and machinery of mining."

A valuable statistical paper upon the development of the coal-field of Great Britain, and the range of prices of coal during a period of upwards of 60 years, was the subject of the President's opening address, while the excavations of the Manchester Ship Canal Company have furnished the theme of not a few of the papers.

Others are connected with the work of the Research Committees of the British Association, which the Society, as one of the Corresponding Societies, is endeavouring to promote. Several of these Committees are formed for objects

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well within the scope and province of the Society, and it is hoped that more help will be forthcoming from the members to aid and promote the ends for which these Scientific Committees have been formed.

The connection which exists between the Society and the Geological collections at the Owens College was again renewed on the 29th of January last by a special evening meeting in the Museum, on which occasion some interesting additions to the collections were made by Mr. Leader Williams and other members.

It is desirable that this social gathering should now be considered as an annual event, whereby the members may be incited to take a warmer interest in the Museum and lead many to a systematic study of the valuable specimens there exhibited.

During the summer two excursions were arranged—one to the Barton Section of the Manchester Ship Canal Works, on the 11th of May; the other to Northwich and the Salt Works, on the 1st of August.

The one to Barton had to be postponed on account of the very heavy rain that prevailed at the time, but subsequently, arrangements were made for the 1st June, when a very successful excursion took place, under the guidance of the Resident Engineer; the walk extending from Mode Wheel to Sticking's Island.

The Northwich excursion was also a complete success, owing to fine weather and the careful arrangements that had been made for the comfort of the party. Two of the members—C. E. de Rance, Esq., F.G.S., and Thomas Ward, Esq., J.P.,—were the appointed leaders, and most efficiently and well did they fulfil the duty. The geological features of the district were described and pointed out, the present subsiding areas due to brine pumping were examined, as

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well as the sites of old salt workings, now covered by what are known as *flashes* or lakes of water.

The Anderton Lift, whereby the canal barges are transferred from the canal to the river Weaver, running some 50 feet below, was also visited under the competent guidance of Mr. Saner, Engineer to the Weaver Trustees, the latter body having most kindly placed a steam-boat at the service of the Society.

Library.—As in preceding years, the Library continues to receive a large addition to its store of Geological and Mining literature, principally by the way of donation and exchange with Corresponding Societies. The purchases have been the following:—Geology, 2 vols., by Professor Prestwich. Fossils of the British Islands, Vol. 1, by Professor Etheridge. The Minerals of New South Wales, by Professor Liversidge.

Upwards of 100 of the principal Geological Societies and Mining Institutes, at home and abroad, are in regular communication by the mutual system of exchange of publications. The volumes so received give an important feature to the Library, which should make it of especial value to the members.

The Council are pleased to note that greater use has been made of the Library during the past year, and that several members, living at a distance, avail themselves of it, by having books sent by parcel or book post.

This gradual increase of the Society's property has, however, its drawback, owing to the limited space at the Society's disposal, and the time is not far distant when additional accommodation will be absolutely necessary.

Whether Manchester will ever be dowered with a suitable building, devoted to the housing of our numerous Literary and Scientific Societies, is still a qnestion of the future, but this seems certain, that it must look rather to private munifi-

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cence than to the combined action of the Societies, to provide such a home, for as a commercial speculation it would probably be a failure. Is it too presumptuous to hope that the attention of the Whitworth Legatees may be turned in this direction, when planning their proposed Whitworth Institute? Liverpool has already such a home for her learned and scientific societies, where, by a small payment, suitable to their means, they are provided with convenient and comfortable quarters.

The Treasurer's Statement is an extremely satisfactory document, demonstrating the careful management and the strong financial position of the Society.

The balance now standing to the credit of the Society is £186 4s. 3d., being the excess of income over expenditure, accumulated during the last few years.

With regard to the disposition of this balance, your Council have empowered the Treasurer to purchase One Hundred Pounds of Lancashire and Yorkshire 4 °/₀ Stock, which will thus raise the amount of the investments on behalf of the Society to the very satisfactory sum of One Thousand Pounds.

The income from this source, it is suggested, might hereafter fittingly be applied to the purchase of books, a more liberal illustration of the Transactions, or to meet any extraordinary expense that may be deemed advisable, while the annual subscriptions would be reserved to meet the current expenses.

In conclusion, your Council in handing over the reins of office to their successors, feel confident that the future of the Society is one full of promise and stability, if the members will only energetically second the efforts of the Council in their endeavour to promote and further those objects which the original founders of the Society had in view.

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Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1888-9.	Abstract of Receipts.	£	s.	d.
Oct. 1.—To	Balance brought down	127	12	3
,,	Birkenhead Dividends	23	8	0
,,	Lancashire and Yorkshire Dividends	11	14	0
,,	Sale of Transactions	4	14	6
,,	Subscriptions, 1888-9	172	0	0
,,	Arrears	13	0	0
,,	New Half-Year Subscriptions	2	0	0
,,	Composition, less Year's Subscription	9	0	0
,,	Bank Interest	1	16	10
		£365	5	7
1889.—Oct. 1.—To	Balance brought down	186	4	3

1888-9.	Abstract of Payments.	£	s.	d.
By	Library	7	17	8
,,	Transactions	76	3	6
,,	Reporters	12	12	0
,,	Circulars and Stationery	11	10	0
,,	Postages and Carriage of Parcels	21	11	2
,,	Meetings—Extra Expenses	1	17	0
,,	Binding	2	10	6
,,	Collectors' Commission	9	7	0
,,	Rent, &c.	30	0	0
,,	Insurance	0	12	6
,,	Gift to C. Hargreaves, omitted 1887-8	2	10	0
,,	Gift to C. Hargreaves, 1888-9	2	10	0
		£179	1	4
,,	Balance	186	4	3
		£365	5	7

The Investments consist of £600 Four per Cent. Guaranteed Stocks of the Birkenhead Railway, and £300 Lancashire and Yorkshire Consolidated Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

HENRY M. ORMEROD, Treasurer.

October, 1889.

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THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE SOCIETY DURING THE SESSION 1888-89.

1888.

November. Knowles, John. "On the Coal Trade."

Dawkins, Professor W. B. "On the Clay Slates and Phyllites of the South of the Isle of Man; and a Section of the Foxdale Mine, Isle of Man."

December. Swete, Oswald R. "A Miner's New Electric Safety Lamp."

Burrows, J. S. "Notes on Working with the Edison-Swan Lamp."

Ormerod, E. "Model of Patent Safety Cage."

De Rance, C. E. "On the Geological Survey of Cheshire."

Grundy, James. "On Stemming of Shot Holes."

1889.

January. Grundy, James. "On the Premature Explosions of Gunpowder."

Hilton, James. "On the Use of Roburite in Coal Mines."

Kendall, Percy F. "The Volcanic Phenomena of Mull." (Given at Owens College.)

February. Roeder, Charles. "The Salt Works at Hale, in Lancashire."

Oldham, Thomas. "On the Cause of Earthquakes, of the Dislocation and Overlapping of Strata, and of similar Phenomena."

Kendall, P. F. "On a large Boulder found in Oxford Street, Manchester."

De Rance, C. E. "The late Earthquake Shock."

March. Knowles, John. "The Earthquake Shock of February 10th, 1889."

Bramall, Henry. "On the Effects of Roburite Fumes."

Roeder, Charles. "Some further Remarks on the Oxford Street Section."

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March.	Fletcher, Herbert. "On the Effects of Goaf Stowing on Sudden Issues of Gas, and on Ventilation."
	Hollingworth, George H. "The Phœnix Patent Safety Lamp."
April.	Roeder, Charles. "On a new Archœological Discovery on the Ship Canal at Sticking Island."
	Watts, William. "On the Use of Roburite and other Explosives in Mines."
	Bolton, Herbert. "On Fish Remains from the Lower Coal Measures."
May.	Various. Discussions on Roburite.
June.	Clifford, William. "Additional Notes on Richmond Coal Field, Virginia."
	Dickinson, Joseph. "On Carbonic Acid Gas or Black Damp, as commonly found in Mines."
	Bird, W. J. "Note on the Seaton Carew Boring."
	Watts, William. "Erratic Boulders and Boulder Clay in Castleshaw Valley."
	Watts, William. "Thermometrical Observations of Atmospheric Air and Water at Piethorne and Denshaw."
	Roeder, Charles. "Some Notes on the Barton Section of the Manchester Ship Canal."
	Stirrup, Mark. "On the Ancient Canoe found at Barton-upon-Irwell.
August.	Clark, C. F. and others. "Discussion on Roburite."

The PRESIDENT said he had much pleasure in moving that the Report which had been read, together with the Treasurer's Statement be received and adopted.

Mr. BARRETT seconded the motion, and it was passed unanimously.

Mr. STIRRUP stated that, in accordance with the Council's resolution, the sum of £100 had been (or would immediately be) invested by the Treasurer in Lancashire and Yorkshire 4 per cent. stock.

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NEW ORDINARY MEMBERS.

Ashworth, Dr. J. W.
Beck, William
Birtwistle, Arthur
Bolton, Edgar O.
Dobbs, Joseph
Foster, John W.
Moore, J. K.
Munro, Donald
Settle, William
Scott, W. B.
Swete, O. R.
Taylor, John
Taylor, Reuben
Taylor, William

MEMBERS DECEASED.

Farrar, James
Hardwick, Charles
Radcliffe, James

MEMBERS RESIGNED.

Gresley, W. S.
Kearsley, William
Lyon, Edward
McAdoo, John
Meadows, Chris.

REMOVED FROM THE LIST.

Arthur, David
Atkinson, Samuel C.
Hargreaves, John
Jackson, William
Robins, George J.
Wood, William

ELECTION OF OFFICERS.

The Hon. Secretary drew the attention of the members to the rules of the Society, which renders it obligatory that a change of President and reconstruction of the Council should take place; the two Vice-Presidents and four Members of the Council who had attended the fewest number of

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Council meetings being ineligible for re-election. The election was then proceeded with, and the following Officers and Council were declared duly elected:—

President:

HENRY HALL, H.M.I.M.

Vice-Presidents:

W. S. BARRETT.
HENRY BRAMALL, M.Inst.C.E.
GEORGE PEACE.
WM. SAINT, H.M.I.M.

Ex-officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
R. CLIFFORD SMITH, F.G.S.
H. M. ORMEROD, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.
PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
JOHN KNOWLES, M.Inst.C.E., J.P.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

MARK STIRRUP, F.G.S. | GEO. H. HOLLINGWORTH, F.G.S.

Other Members of the Council:

WILLIAM BRYHAM, JUNR.
JOHN S. BURROWS, F.G.S.
WALTER EVANS.
JAMES GRUNDY, H.M.I.M.
WILLIAM JOHNSON.
GEORGE H. PEACE.
CHARLES PILKINGTON.
JOHN RIDYARD.
JAMES TONGE, F.G.S.
WILLIAM WATTS, F.G.S.
GEORGE WILD.
ROBERT WINSTANLEY.

Hon. Auditors:

ALFRED PILKINGTON. | CLEGG LIVESEY.

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Mr. Stirrup said the formal business of the meeting being concluded, he wished to draw the attention of the members to a paragraph in the circular calling the meeting, which said:—

"Members desirous of reading Papers, or making short communications during the ensuing Session, will much oblige the Hon. Secs., and facilitate the arrangement of the programme, if they will send in as *early as possible* the titles of their subjects, and the date they would prefer."

Gentlemen would be aware that it was very necessary that the Secretaries should be provided with material for the forthcoming meetings. He might say that he had a promise from Mr. Ward, of Northwich, of a paper on the American Salt Fields. Mr. Ward had recently visited the United States on behalf of the Salt Syndicate, and he (Mr. Stirrup) thought he would have some very valuable information to bring before the Society. There were also one or two other papers in prospect: one was on the Geology of St. David's district, by a gentleman with whom he had been in correspondence for the last 18 months, and who had previously offered his aid to any of the members who might visit that district. There were also other papers which he (Mr. Stirrup) hoped to be able to secure. One thing he wished strongly to urge on the consideration of members—that was, the necessity for a constant accession of new members. Of course, a Society like theirs was continually losing members by death and change of residence, and it was most desirable that others should be found to take their places. They had maintained their ground pretty well last year, and he hoped in the ensuing year they would do even better. It was, moreover, advisable that they should have new members joining as early as possible in the Session; it was an advantage both to themselves and to the Society.

Professor Boyd Dawkins said he hoped before long to

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have a communication to make to the Society with reference to the boring in the neighbourhood of Dover.

Mr. STIRRUP: We propose, if the authorities will allow us, to have a meeting at the Owens College again in January.

Professor BOYD DAWKINS: Nothing will give us greater pleasure than to welcome this Society to Owens College at any time.

Mr. STIRRUP then moved a vote of thanks to the retiring President, remarking that they all felt how excellently well Mr. Knowles had filled that position. He had given them one of the most valuable papers on the production of Coal that had appeared in any periodical for years past.

The resolution was duly seconded, and carried unanimously.

The PRESIDENT, in returning thanks, said it had been a pleasure to him to associate himself again with the members of that Society, and to take an active part in the meetings. It must be expected that, with the large amount of work he had on his hands, he was pretty well tied, especially on Tuesdays, but the change made last year in the day of meeting, from the first to the second Tuesday in the month, gave to him and other members who were connected with collieries, a chance of attending the meetings more regularly. He hoped this would continue. He was glad to see that the Society kept up its numbers, and he trusted that they would try and encourage larger attendances at the monthly meetings.

Mr. C. PILKINGTON moved a vote of thanks to the Honorary Secretaries. He observed that those gentlemen had had a good deal of work to do during the past year, and it would be equally heavy in the coming Session. They deserved the best thanks of the members.

The motion was seconded, and carried unanimously.

Mr. STIRRUP, replying for himself and his colleague, said it was a pleasure to them to conduct the Society's business. Personally, he had its welfare at heart, or he could not devote so much time as he did to it. The Society was welcome to any services that he was able to render.

This concluded the business of the meeting.

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APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1888-89.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1887-8. *From the Society.*

Bristol Naturalists' Society.—Proceedings, Part 3, Vol. V.; Part 1, Vol. VI. *From the Society.*

Chester Society of Natural Science and Literature.—Annual Report, 1888-9.

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Part 8, Vol. XV.; Parts 1-4, Vol. XVII. *From the Institute.*

Cornwall.—Mining Association and Institute of Cornwall. Report of Eighth Exhibition. Transactions. Part 1, Vol. II. *From the Institute.*

Cornwall.—Transactions of the Royal Geological Society of. Part 3, Vol. IX. *From the Society.*

Cornwall.—Royal Institution of. Journal, Part 3, Vol. IX. *From the Council.*

Dublin.—Royal Dublin Society. Scientific Proceedings. Parts 7-8, Vol. V.; Parts 1-6, Vol. VI. Scientific Transactions. Vol. III., Series 2, No. 14; Vol. IV., Series 2, Nos. 1-5.

Dublin.—Royal Geological Society of Ireland. Journal, Part 2, Vol. XVII., 1885-7. *From the Society.*

Edinburgh Geological Society.—Transactions. Part 4, Vol. V. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings, Session 1887-88. *From the Society.*

Essex Naturalist.—Nos. 7-12, Vol. II., 1888. *From the Essex Field Club.*

Glasgow.—Natural History Society of. Proceedings and Transactions. Part 1, Vol. II., New Series, 1886-7. *From the Society.*

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Glasgow—Geological Society of Glasgow. Transactions. Part 2, Vol. VIII. *From the Society.*

Halifax.—Geological and Polytechnic Society of Yorkshire. Proceedings. New Series, Part 1, Vol. XI. *From the Society.*

Hertfordshire Natural History Society and Field Club.—Transactions. Part 9, Vol. IV.; Parts 1-5, Vol. V. *From the Society.*

Leeds Geological Association.—Transactions. Part 4, 1888. *From the Association.*

Leeds Philosophical and Literary Society.—Annual report, 1888-9.

Leicester Literary and Philosophical Society.—Transactions. Parts 8-11, 1889. *From the Society.*

Liverpool Geological Society.—Proceedings. Part 4, Vol. V. *From the Society.*

Liverpool Geological Association.—Transactions. Vol. VIII., Session 1887-8. *From the Association.*

Liverpool Science Students' Association.—Proceedings and Report, 1887-8.

London Geological Society.—Quarterly Journal. Nos. 175-8, Vol. XLV. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 7-9, Vol. X.; Nos. 1-3, Vol. XI. Contents and Index, Vol. X. *From the Association.*

London Geological Magazine.—Nos. 290-302. *Purchased.*

London Institute of Mechanical Engineers.—Proceedings. Nos. 2-4, 1888; No. 1, 1889. *From the Institute.*

London.—Iron and Steel Institute.—Journal. No. 1-2, 1888. *From the Institute.*

London.—British Association Report.—Bath Meeting, 1888. *Presented by the Association.*

London.—Palæontographical Society. Vol. XLII., 1888. *Purchased.*

London.—Year Book of Scientific Societies. 1889. *Purchased.*

London.—Royal Institution of Great Britain.—Proceedings, Part 2. Vol. XII. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 268-272, Vol. XLIV.; Parts 273-279, Vol. XLV.; Part 280-281, Vol. XLVI. *From the Society.*

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Manchester Association of Engineers.—Transactions, 1888; 33rd Annual Report, 1888. Four Pamphlets. *From the Association.*

Manchester Literary and Philosophical Society.—Memoirs, Vol. I. Fourth Series. *From the Society.*

Manchester Field Naturalists' and Archæologists' Society.—Report and Proceedings for 1888. *From the Society.*

Manchester Microscopical Society.—Annual Report, 1888. *From the Society.*

Midland Institute of Mining Engineers.—Transactions. Parts 96-102, Vol. XI. *From the Institute.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Parts 5-6, Vol. XXXVII.; Parts 1-3, Vol. XXXVIII. *From the Institute.*

North Staffordshire Naturalists' Field Club.—Annual Report and Transactions, 1888 and 1889. *From the Club.*

Scotland—Mining Institute of Scotland.—Transactions. Parts 3-9, Vol. X.; Parts 1-3, Vol. XI. *From the Council.*

Southampton—Hampshire Field Club.—Papers and Proceedings. Nos. 1-2. *From the Club.*

South Wales Institute of Engineers.—Proceedings. Parts 1-3, Vol. XVI., and Rules. *From the Institute.*

Yorkshire Geological and Polytechnic Society.—Proceedings. Vol. X. History of the Society, 1837-1887. *From the Society.*

Organization of the Fossil Plants of the Coal Measures. Part 15. By Professor W. C. Williamson, LL.D., F.R.S. *From the Author.*

Congrès Géologique International, Fourth Session, London, 1888, Explication des Excursions. *From M. Stirrup.*

North Shields, Potts' Mining Register and Directory for 1889. *Presented by Publisher.*

Changes in the Earth's Crust, by Dr. Ricketts: Pamphlet.—*From the Author.*

Etheridge's British Fossils-Palæozoic. Vol. I. *Purchased.*

Prestwich's Geology, Chemical, Physical, and Stratigraphical. Two Vols. *Purchased.*

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Deep Borings in Trias, Teignmouth. Pamphlet by G. W. Ormerod. *Presented by Author.*

Mixed Accidents in Mines. By A. R. Sawyer. *Presented by the Author.*

Mining Manual for 1888. *Presented by W. R. Skinner.*

Journal of British Society of Mining Students, May, 1888. *Presented by W. S. Gresley.*

The following Books and Pamphlets were presented by Mr. William Whitaker, F.G.S.:—

Geological Sketches of the Precious Metal Deposits of Western ,U.S.A., 1885.

Bulletin U.S. Geological Survey of Territories. No. 1, Vol. V., 1879.

Mines and Minerals of British Columbia. G. M. Dawson, 1877.

Work of International Congress of Geologists. Pamphlet by G. K. Gilbert, 1887.

Pamphlet, Chotts Tunisiens, Hydrologie, &c., 1881.

Pamphlet, Der alte Bergsturz im H. A. Heim, 1883.

Pamphlets, Geological Survey of Great Britain, Explanations of Horizontal Sections. Sheets 18, 41, 42, 54, and 61.

Stratigraphical System of Organised Fossils. By W. Smith, 1817.

Pamphlet, American Geological Classification and Nomenclature. By Jules Marcou, 1888.

Pamphlet, Führer Kgl. Mineralogische, Geol. Museum zu Dresden, 1887.

Pamphlet, Den Norske Nordhaus Expedition. Chemi, 1882.

List of Works on the Geology, Mineralogy, and Palæontology of Shropshire. Pamphlet, by W. Whitaker.

Report on the Tertiary Lignite Formation near 49th Parallel. Pamphlet, by G. W. Dawson.

Annales des Sciences Géologiques. Vol. III., 1881. By M. Vasseur.

Nitrate and Guano Deposits of Atacama.

Introductory Lectures at Museum of Practical Geology. By Edw. Forbes, John Percy, A. C. Ramsay, W. W. Smith. Four Pamphlets.

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Introductory Lecture, University College, London. By A. C. Ramsay. Pamphlet.

Mensch und Eiszeit. Dr. Albrecht Penck. Pamphlet.

History and Methods of Palæontological Discovery. Professor O. C. Marsh. Pamphlet.

List of Palæozoic Fossil Insects. By R. D. Lacoe. Pamphlet.

Review of Modern Doctrine of Evolution. By E. D. Cope. Pamphlet.

The Taconic Question re-stated. By T. Sterry Hunt. Pamphlet.

Die Geologische Landesuntersuchung des Königreichs Sachsen, 1878-81. By Prof. Credner. Pamphlet.

The Valley of the Soar. By J. D. Paul. Pamphlet.

Académie de Lausanne. Installation de MM. Maurer, Renevier et Rambert. Pamphlet.

Prospectus of International Mining and Smelting Company, Winnipeg. Pamphlet.

Annual Reports, from the Committees.

Bradford Free Libraries.—Eighteenth Annual Report.

Cambridge University.—23rd Annual Report of the Library Syndicate.

Devon and Exeter Albert Memorial Museum.—Report, 1888 and 1889.

Liverpool Free Library and Museum.—36th Annual Report, 1888.

Manchester.—Owens College.—Calendar. 1888-9.

Salford Museum, Libraries, and Parks.—Annual Report, 1887-8.

Canada and U.S. America.

Canada.—Ottawa.—The Canadian Mining Review. Nos. 7-12, Vols. VI., VII.; Nos. 1-7, Vol. VIII. *From the Editor.*

Canada.—Ottawa.—Geological and Natural History Survey of Canada.—Maps to Vol. II., 1885. *From A. R. C. Selwyn, F.R.S., Director of the Survey.*

Canada.—Canadian Institute, Toronto.—Proceedings. Nos. 1-2, Vol. VI., 3rd Series; Annual Report, 1887-8. *From the Institute.*

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Eozoon Canadense: Its Geological and other Relations. By Sir J. W. Dawson. Eozoic and Palæozoic Rocks of Atlantic Coast of Canada By Sir J. W. Dawson. Notes on Balanus Hameri. By Sir J. W. Dawson. Notes on Cretaceous Plants from Port Mc.Neill. Pamphlets. By Sir J. W. Dawson. *From the Author.*

Halifax, N.S.—Nova Scotian Institute of Natural Science.—Proceedings and Transactions. Part 2, Vol. VII., 1887-8. *From the Institute.*

U.S.A., Cambridge.—Harvard College.—Annual Report of the Curator of the Museum of Comparative Zoology, 1887-8.—Bulletin of the Museum of Comparative Zoology. No. 10, Vol. XIII.; Nos. 2-5, Vol. XVI.; Nos. 1-3, Vol. XVII.—Harvard University Bulletin. No. 42, January, 1889. *From Alexander Agassiz.*

U.S.A., Chapel Hill, North Carolina.—Elisha Mitchell Scientific Society.—Journal. Part 2, 1887; Parts 1-2, 1888. *From the Society.*

U.S.A., Denver.—Colorado Scientific Society.—Proceedings. Part 3, Vol. II.; Part 1, Vol. III. *From the Society.*

U.S.A., Minnesota.—Geological and Natural History Survey of. 16th Annual Report for year 1887. *From N. H. Winchell, State Geologist.*

U.S.A., New York.—American Institute of Mining Engineers.—Transactions. Vol. XVI. *From the Institute.*

U.S.A., New York.—American Museum of Natural History.—Annual Reports, 1887-8 and 1888-9.—Bulletin. No. 2, Vol. II., March, 1889. *From the Trustees.*

U.S.A., Ohio.—Geological Survey of Ohio.—Economic Geology and Maps. Vol. VI. *From Edward Orton, State Geologist.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 1-3, 1888. *From the Academy.*

U.S.A., Philadelphia.—Journal of Franklin Institute. No. 1, Vol. XCI.; Nos. 753-756, Vol. CXXVI.; Nos. 757-762, Vol. CXXVII.; Nos. 763-4, Vol. CXXVIII. *From the Institute.*

U.S.A., Philadelphia.—Pennsylvania Geological Survey. Annual Report and Atlas, 1886, Part 4; Atlas of Northern Anthracite

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Coal Field, Part 2; Atlas of Eastern Middle Coal Field, Part 2. *From the Board of Commissioners.*

U.S.A., Sacramento.—8th Annual Report of State Mineralogist, California, 1888.

U.S.A., Scranton, Pennsylvania.—The Colliery Engineer. No. 12, Vol VIII.; Nos. 1-12, Vol. IX.; No. 1, Vol. X. *From the Editor.*

U.S.A., Washington.—United States Geological Survey. Monograph, Vol. XII., and Atlas; Geology of Leadville, Colorado; Bulletin, Nos. 40-47, 1887; Mineral Resources of United States, 1887. *From the Director of the Survey.*

U.S.A,, Washington.—Smithsonian Institution. Annual Report, 1885, Part 2; 1886, Part 1. *From the Board of Regents.*

INDIA.

Calcutta.—Records of the Geological Survey of India. Parts 2-4, Vol. XXI.; Parts 1-2, Vol. XXII. *From the Governor-General of India in Council.*

AUSTRALIA.

Melbourne.—Geological Society of Australasia. List of Members. Transactions. Part 3, Vol. I.

Sydney.—Royal Society of New South Wales. Journal and Proceedings. Parts 1-2, Vol. XXII., 1888. *From the Society.*

Sydney.—New South Wales.—Department of Mines.—Annual Report, 1887. *From the Government.*

Sydney.—Geological Survey of New South Wales. Memoir No. 1, Palæontology, 1888; Memoir, Palæontology, No. 2; Tertiary Flora of Australia; Records of Geological Survey of New South Wales, Part 1, Vol. I., 1889; Descriptive Catalogue of Exhibit of Metals, Minerals, &c., at Melbourne International Exhibition, 1888. *From the Hon. the Minister of Mines.*

Victoria.—Gold Fields of. Reports of Mining Registrars. June, September, and December, 1888. *From the Government.*

Victoria.—Annual Report of Mines and Water Supply. 1887.

Victoria.—Mineral Statistics of 1887. *From the Government.*

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Victoria.—Natural History of. Prodromus of the Zoology, 1888 *From Fred Mc. Coy, F.R.S., Director of the Victoria Museum, Melbourne.*

New Zealand.—Reports of Mining Industries, 1888. *From the Government.*

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 1-4, Band XL. *From the Society.*

Brussels.—Société Malacologique de Belgique. Procès-Verbeaux, Vol. XVII., 1888; Annales, Vol. XXII., 1887. *From the Society.*

Brussels.—Sur la découverte à Ixelles, d'un Ossuaire de Mammifères. Sur le Gisement des Silex Taillés attribues à l'Homme Tertiaire. 2 Pamphlets. *From the Author, M. Mourlon.*

Brussels.—Catalogue Illustré des Coquilles Fossiles d' Eocéne de Paris. *Purchased.*

Buenos Ayres.—Estadistica de Comercio e Navigacion de Rep. Argentine, 1888. Datos Trimestrales del Comercio Exterior, No. 59, 1888; Los presupuestos, los recursos y los Leyes, &c.; Censo Municipal, 1887. *From the Government.*

Christiania.—The Probable Cause of the Displacement of Beach Lines: Pamphlet by Professor A. Blyth. Additional Note by Professor A. Blyth.

Christiania.—Variations of Climate in Course of Time: Pamphlet by Professor A. Blyth. *From the Author.*

Christiania.—Royal University of Norway. Reusch Bömmeleön, with English Summary, 1888. *From the University.*

Dresden.—Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis in Dresden. January to June, 1888; July to December, 1888. *From the Society.*

Halle, a/S.—Vereins für Erdkunde, 1888. *From the Society.*

Halle, a/S.—Die Kaiserliche Leopold-Carol. Deutschen Akademie. Leopoldina, 1886-7; Die Versteinerungen des Cambrischen Schichten Systems der Insel Sardinia, Nos. 1-33; Leopoldina, Heft 24; Elephas Antiquus, by Dr. Pohlig. *From the Academy.*

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Igló.—Jahrbuch des Ungarischen Karpathen-Vereins. 16, 1889. *From the Society.*

Kieff.—Russia.—La Société des Naturalistes. Mémoires, Vol. IX., Books 1-2; Proceedings, Vol. X., No. 31, 1889. *From the Society.*

Lausanne.—Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 98-99, Vol. XXIV. *From the Society.*

Lille.—Société Géologique du Nord. Annales 14. *From the Society.*

Naples.—Accademia del Scienze Fisiche e Mathematiche. Rendiconti, Fasc 1-3, 6-10, Vol. II., Series 2, 1888; Fasc 1-12, Vol. I., Series 1, 1887. *From the Academy.*

Paris.—Revue de le Legislation des Mines. July-December, 1888; January-June, 1889. *Purchased.*

Paris.—Sur un Nouveau Poisson Fossile. Pamphlet by Chas. Brongniart; Les Blattes de l'Epoque Houillère, Pamphlet by Chas. Brongniart. *Presented by the Author, M. Charles Brongniart.*

Paris.—Annuaire Géologique Universel: Vol. IV., 1888. *From Dr. Dagincourt.*

Pisa.—Atti della Società Toscana di Scienze Naturali. Vol. IX.; Processi Verbali, Vol. VI., 1889. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Memorie. Vols. III. and IV., Series 4. Rendiconti. Fasc. 11 and 12, Vol. IV.; Fasc. 1-8, Vol. V. *From the Academy.*

San José.—Rep. de Costa Rica. Argument and Reply on the Question of the Treaty of Limits between Costa Rica and Nicaragua, 1887. *By P. P. Zeleden.*

St. Petersburg.—Academie Impériale des Sciences. Bulletin. Nos. 2-4, Tome XXXII. Memoires. Nos. 1-16, Tome XXXVI. *From the Academy.*

St. Petersbourg. — Institut des Mines. Comité Géologique. Mémoires. Nos. 2-4, Vol. V.; No. 6, 2 Parts, Vol. VI.; Nos. 1-2, Vol. VII.; Bulletins Parts 11-12, Vol. VI.; Nos. 1-5, Vol. VII.; Supplement to Vol. VII. *From the Minister of Domains.*

Wien.—Vereine der Geographen der Wien. Bericht 14, Vereinsjahr. *From the Society.*

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BOOKS PURCHASED, 1888-9.

British Fossils, Palæozoic. Vol. I. By Prof. Etheridge.

Catalogue Illustré des Coquilles Fossiles d'Eocene de Paris.

Geology, Chemical, Physical, and Stratigraphical. 2 Vols. By Professor Prestwich.

Geological Magazine.

Palæontographical Society's Monograph. Vol. XLII., 1888.

Revue de la Legislation des Mines. Paris.

Year Book of Scientific and Learned Societies. 1889.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London ..... British Museum.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College Gower Street, W.C.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester ..... The Manchester Association of Engineers, 18, Hullard Street, Old Trafford.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Sooiety.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association, 36, George Street.

Barnsley ..... Midland Institute of Mining Engineers.

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Birmingham.....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Burlington Chambers, New Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge.....Geological Museum, University.
University Library.

Chester .....Society of Natural Science.

Chesterfield .....Institution of Mining Engineers, 13, Cavendish Street.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.

Tuckingmill, Camborne ....Mining Association and Institute of Cornwall.

Essex.....Essex Field Club, 8, Knighton Villas, Buckhurst Hill, Essex.

Exeter .....Albert Memorial Museum.

Falmouth .....Falmouth Naturalist Society, De Beauvoir House.

Halifax.....Geological and Polytechnic Society of Yorkshire.

Leeds.....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Sunny Bank).

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society.
Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne..North of England Institute of Mining and Mechanical Engineers.

Newcastle, Staffordshire ....North Staffordshire Naturalists' Field Club, (Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage).

Norwich .....Geological Society, Museum.

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Oxford .....Bodleian Library.
Radcliffe Library.
North Shields ....Public Free Library.
Southampton.....Hampshire Field Club, Hartley Institution.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Warwick .....Natural History Society.
Watford, Herts ..Hertfordshire Natural History Society and Field Club, the Public Library, Watford.
Wigan .....Free Library.
Mining School.

II.—SCOTLAND.

Dundee.....Free Library and Museum.
Edinburgh.....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow.....Geological Society.
Natural History Society.
Hamilton .....Mining Institute of Scotland.

III.—IRELAND.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast .....Natural History Society, The Museum.

IV.—AUSTRALIA.

Melbourne.....Geological Society of Australasia, 17A, Queen Street.
Public Library of Victoria.
Sydney .....Free Public Library.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines.—The Honourable the Minister of Mines.

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V.—Canada.

Hamilton .....Hamilton Association.

Ottawa.....Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S., Director, Museum, Sussex Street, Ottawa).
M'Gill College (Principal, Sir J. W. Dawson, F.G.S.)
Editor of Canadian Mining Review.

Toronto.....Canadian Institute.

VI.—United States.

Boston, U.S......Free Library.

Chapel Hill, North Carolina, U.S. } The Elisha Mitchell Scientific Society.

Columbus, U.S.....Ohio, Geological Survey of (Professor Edward Orton, State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana, U.S. ....Department of Geology and Natural History.

Indianopolis, U.S...Professor John Collett, State Geologist.

Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.

New York, U.S. ..American Institute of Mining Engineers (R. W. Raymond, Box, 223, New York City).

New York.....American Museum of Natural History, Central Park.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.

Shenandoah, Pa. ..Editor of the Colliery Engineer.

Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wyoming, U.S. ..Historical and Geological Society.

VII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.
Gesellchaft fur Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

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Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres ....Officiana Nacional de Commercie.

Calcutta .....Geological Survey of India.

Christiania .....Royal University of Norway.

Dresden .....Naturwissenschaftiche Gessellschaft Isis.

Halle, A.S......Verein fur Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Kazan, Russia ....La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*)..Société Vaudoise des Sciences Naturelles.

Löcse, Hungary ..Société Hongroise des Carpathes (Centrale in Leutschau).

Lille.....Société Geologique du Nord.

Naples .....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.

Paris .....Annuaire Géologique Universel (Dr. Dagincourt, 15, Rue de Tournon).

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ....Museo Nacional.

Rome.... .... ..Reale Accademia dei Lincei.

St. Petersburg ....Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Turin .....Acadêmie Royale des Sciences.

VIII.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.

Geological Record, W. Topley, F.G.S., Museum, Jermyn Street, London, S.W.

Mining Journal, Fleet Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

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PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.

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LIST OF MEMBERS.

OCTOBER, 1889.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withings Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, 231, Ince Green Lane, Lower Ince, near Wigan.
1888	Ashworth, J. W., M.R.C.S., F.G.S., Thorn Bank, Heaton Moor, Stockport.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 24, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Newcastle, Staffordshire.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool, *Vice-President*.
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1889	Beck; William, Ellerbeck Collieries, near Chorley.
1885	Beswick, James, Rock Villa, Hoddlesden, Darwen.
1877	Bickerton, Charles W., Hazel Grove, near Stockport.
1889	Birtwistle, Arthur, Great Harwood Collieries, nr. Blackburn.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington.

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Year of Election.	
1887	Boole, George, Rainford Colliery, near St. Helens.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester. *Vice-President.*
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck Ernest Van den*, 124, Rue Terra Neuve, Brussels.
1877	*Brongniart Charles*, F.E.S., 8, Rue Guy-de-la-Brosse, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, 33, Trafalgar Road, Birkdale, Southport.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, William, jun., Douglas Bank Colliery, Wigan. *Member of Council.*
1882	Burnett, R.T., F.G.S., 1, Cavendish Road, Birkdale, Southport.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., F.G.S., Yew Tree House, Atherton, near Manchester. *Member of Council.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1887	Chandley, Charles, Atherton, near Manchester.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1889	Clay, Richard, Dukinfield Coal Company, Dukinfield.
1886	Clifford, William, Norton Woodseats, Sheffield.
1882	Cockson, Charles, King Street, Wigan.
1878	Cooke, Charles, Pillowell Colliery, Whitecroft, near Lydney, Forest of Dean, Gloucestershire.
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*

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Year of Election.	
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, co. Kilkenny.
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1865	Evans, Walter, Longsight, Oldham. *Member of Council.*
1880	Fairclough, William, Leigh, near Manchester.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1889	Foster, John W., 6, North Street, New Silksworth, Sunderland.
1873	Garforth, W. E., Halesfield, Normanton.
1884	Garside, Sampson, Denton and Haughton Collieries, Denton.
1874	*Geikie Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan. *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past-President.*

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Year of Election.	
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, jun., 71, Dickinson Road, Rusholme, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborn Hall, Newton-le-Willows.
1888	Grundy, James, H.M. Inspector of Mines, Gordon House, 343, Derby Street, Bolton. *Member of Council.*
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1887	Hallas, Geo. H., Wigan and Whiston Coal Company, Ltd., Prescot.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot, *President.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, 72, Hawkshead Street, Southport.
1885	Hindley, C. E., Polygon, Eccles.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Cossall Colliery, near Nottingham.

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Year of Election.	
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Hon. Secretary.*
1884	Howat, Andrew, 25, Mill Street, Ancoats, Manchester.
1878	Howell, John, Bradley Fold Colliery, near Bolton.
1887	Hughes, James, The Hanley and Bucknall Coal Co., Ltd., Bucknall, Stoke-on-Trent, Staffordshire.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward,* M.A., F.R.S., 5, Raglan-rd., Dublin.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Hartford House, Werneth, near Manchester.
1887	James, J. Stanley, M.E., Leigh, Lancashire.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Westholme, Alsager, Cheshire.
1882	Johnson, William, Abram Colliery, Wigan. *Member of Council.*
1879	*Kinahan, G. H.,* M.R.I.A., 132, Leinster Road, Rathmines, Dublin.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester, *Past-President.*
1889	Knowles, James. Pearson, Knowles & Co., Wigan.
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury, *Past-President.*
1889	Knowles, John. Pearson, Knowles & Co., Wigan.
1882	Knowles, Israel, Ince, Wigan.
1877	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Arncliffe, Cheetham Hill.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Hon. Auditor.*

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Year of Election.	
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 6, De Grey Road, Leeds.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1873	*Martin, Joseph S.*, F.G.S., H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1889	Moore, J. K., C.M., 36, Prince's Street, Douglas, Isle of Man.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1888	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., F.G.S., Carlton Buildings, Cooper Street, Manchester.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1887	Oldham, Thomas, Holmefield, Sale.
1888	Oliver, Samuel A., King Street, Wigan.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth, *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester, *Hon. Treasurer and Past-President.*
1874	*Owen, Sir Richard,* D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, Monton Grange, Eccles. *Member of Council.*

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Year of Election.	
1877	Peace, Maskell W., F.G.S., 18, King Street, Wigan.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester. *Member of Council.*
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1887	Platt, Samuel Sydney, Assoc.M.Inst.C.E., 14, King Street South, Rochdale.
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton. *Member of Council.*
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1887	Saint, William, H.M., Inspector of Mines, 24, George Street, Cheetham Hill. *Vice-President.*
1888	Scarborough, George Edward, Colliery Manager, New Town and Meadows Collieries, Wigan.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1887	Scott, Frederic W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Madeley Coal & Iron Co., Limited, Madeley, near Newcastle, Staffordshire.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*

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Year of Election.	
1884	Simpson, W. W., Winkley, near Whalley, Blackburn.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	*Smethurst, William, F.G.S.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, J. & P. Higson, 18, Booth Street, Manchester.
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bury.
	Stechert, G. E., 30, Wellington Street, Strand, London, W.C.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Swan Lane Brick and Coal Company, Hindley Green, near Wigan.
1889	Swete, Oswald R., Electric Lamp Co., Crown Works, Guildford Street, Lambeth, S.E.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1889	Taylor, John, Great Harwood Collieries, near Blackburn.
1889	Taylor, Reuben, Pendlebury Colliery, near Manchester.
1889	Taylor, William, Whitebirk, Blackburn.
1880	Teale, William E., Sindsley House, Swinton, near Manchester.
1884	Toman, Daniel, Chamber Colliery, Oldham.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.

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Year of Election.	
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton. *Member of Council.*
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1886	*Trafford, Sir Humphrey Francis De, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1887	Walkden, Richard, Colliery Manager, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1886	Wallwork, John, Clifton Moss Colliery, Clifton, Manchester.
1888	Walmesley, Oswald, 3, Montagu Square, London, W.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, High Lane, near Stockport.
1885	Ward, Thomas, J.P., Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Member of Council.*
1878	Wells, Samuel B., General Manager Bengal Coal Co., Limited, Raniganj, India.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1884	Whitehead, John, Chorley, Lancashire.
1867	Wild, George, Albert Street, Bardsley, Ashton-under-Lyne. *Member of Council.*
1880	Williams, E. Leader, M.Inst.C.E., Manchester Ship Canal Co., Deansgate, Manchester.
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., Egerton Road, Fallowfield.
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Member of Council.*
1886	*Wood, Guy, 71, King Street, Manchester.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XX. SESSION 1889-90.

The ORDINARY MEETING of the Members was held on Tuesday, November 12th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, HENRY HALL, Esq., in the Chair.

NEW MEMBERS.

The following gentlemen, having been proposed, were balloted for and duly elected Ordinary Members of the Society:—

Mr. JAMES KNOWLES (Pearson, Knowles & Co.), Wigan.
Mr. JOHN KNOWLES (Pearson, Knowles & Co.), Wigan.
Mr. RICHARD CLAY (Dukinfield Coal Co.), Dukinfield.

Mr. MARK STIRRUP (Honorary Secretary) laid before the meeting several communications which he had received. One of these was a circular from the Honorary Secretaries of the Literary and Philosophical Society, inviting the members to sign a memorial to the Mayor of Manchester in which his Worship was asked to call a public meeting for the promotion of a memorial to the late Dr. James Prescot Joule.

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Mr. Stirrup also announced the gift of sundry interesting pamphlets from Mr. De Rance, of the Geological Survey, including one on "Salt Making Processes in the United States," by Thomas M. Chatard.

The thanks of the Society were given to Mr. De Rance for his kind donation.

Mr. Stirrup further stated that he had received a letter from the Carbonite Syndicate Company, offering facilities for the testing of "Carbonite."

He replied to the effect that the Society, as a Society, was not conducting any test experiments, but that some of the members had undertaken experiments with regard to *roburite*, the results of which had been laid before the Society at its meetings; and he thought it might possibly be that some members who were interested in the use of these explosives in mining, would probably be glad to experiment with carbonite in the same way, and state the results. If any gentleman should desire to correspond with the Carbonite Syndicate with that view, he should be pleased to furnish him with the address of the Secretary.

The President said: Before proceeding with my address I should like to take the opportunity of thanking you for the high honour you have done me in electing me President of this Society for the coming year; and at the same time I would ask for your forbearance in regard to any shortcomings in conducting the business of the meetings. I think it is very important that the President should always, if possible, attend the meetings; and I may say, as far as I am concerned, that that will always be a pleasant duty. Then, in order to have a successful Society you must have papers. I do not think the papers need be very

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lengthy or elaborate, so long as they contain something likely to raise an interesting discussion. I think also, for a successful Society, you must have members: the more members you have the more papers you will have, and the better meetings you will have. Any one who can should endeavour to assist the Society by trying to get gentlemen to join who they think would add to the efficiency of the Society. In that direction I shall use every possible endeavour myself.

THE PRESIDENT'S ADDRESS.

"THE DURATION OF OUR COAL SUPPLY."

By Henry Hall, Esq., H.M.I.M.

I address this Society with great diffidence, more especially as many of its members are eminent authorities on the science of Geology, a science to which I have personally given little attention, except so far as it bears upon mining operations.

This being so, I have had considerable difficulty in selecting a subject for an address, but knowing that this Society is mainly composed of two classes of Members, who may be distinguished as "Geologists" and "Miners"; I have ventured to think that the duration of the coal supply of the United Kingdom, may be of some interest to both sections.

Before proceeding to deal with that subject in detail, I should like to say a few words on the general usefulness of Societies such as this.

The Manchester Geological Society was founded in the year 1838, and now numbers 213 members, it has had a fairly prosperous career.

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The object of its foundation was, no doubt, the same as that of numerous similar Societies, viz., to take advantage of any special knowledge possessed by individuals and make it common property, and by means of argument and discussion and comparison of experiences, to sift thoroughly any difficult question and diffuse the information thus obtained. There are persons so satisfied with their own attainments that they hold almost in contempt the idea that it may be possible to learn from the experience of others. We all know the proverb that "one man's experience is the wisdom of fools," a proverb which when applied to mining and geological matters has certainly a great deal of truth in it.

It is terrible to think of the waste of time and energy a man who finds himself on being "practical" will spend in overcoming difficulties which need never have arisen, if the "practical" man had kept his eyes open and been willing to take a hint from his neighbours. A friend of mine was putting in "endless rope haulage" a short time ago, and noticing that the trams seemed to do anything *but* keep the track, I asked him if he had seen the system in operation anywhere, suggesting that it might save trouble if he were to take an opportunity of seeing how others overcame the little difficulties.—His reply was "No, I mean to fight it out myself." At what loss of time and money to his employers, the sequel would show. The advancement of a profession can only be attained by the varied experiences and discoveries of its various members being brought under review, and this can only be done by meeting together from time to time and comparing the results of different methods of operating—and time—even the time of a busy man, is well spent in attendance at such meetings. I know that some *do* grudge the time thus spent and complain of too much theorising by Scientific Societies, but so far as this

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Society is concerned at any rate, the papers read are generally eminently practical, and such as might satisfy the greatest lover of "rule of thumb." I would say to all, and especially to those who are young and looking forward to rising in their profession, become members, and make a point of attending the meetings and learning to have a better reason for adopting any particular course than that your fathers or grandfathers did so and so.

And I think such Societies, when well supported, serve also another object, they give a standing and an importance to the profession with which they are connected, and at times are useful to defend a profession when attacked either by irksome legislation or from other quarters. On these grounds alone it is to all our interests to support such a Society, for we cannot disguise the fact that in these days, weakness invites attack.

It is now twenty years since the Royal Commission reported on the probable duration of the coal supply of the British Islands, and I think it will be interesting to see how far the estimate then made has been verified.

The Commission was thought desirable at that time to allay or justify some excitement caused by opinions expressed by Professor Jevons, to the effect that the coal supply of the United Kingdom was being *rapidly* exhausted. I believe he made out that we should be reduced to sore straits for coal at the end of a hundred years. Among the names of eminent men who were elected to serve on the Commission, of which the Duke of Argyle was Chairman, I see the name of one of the Past Presidents of this Society, Mr. Dickinson.

The Report which was made on the 27th July, 1871, after some five years labour was most able and complete, and embraced the result of searching enquiries into every phase of

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the subject, and no one who looks through the Report can fail to be struck by the amount of industry it displays.

The enquiry naturally divided itself into several branches, but the two great questions to be solved were—

1. The quantity of coal available in these islands, that is coal which might fairly be considered to be within the reach of mining appliances.

2. The rate and progress of consumption—this latter being much the most intricate and difficult of solution.

In order to arrive at anything like a correct estimate of the quantity of coal available, the extent of known coalfields had to be ascertained, the probability of fresh coalfields being discovered had to be considered, and the depth to which workings could be carried had to be decided. The Commissioners proceeded by means of committees to sift these questions.

The extent of the known coalfields it was possible to ascertain with some degree of certainty, and the Report fixes this quantity at 90,207 millions of tons at depths not exceeding 4,000 feet, and exclusive of the coal overlaid by the Permian, New Red Sandstone, &c.

Of this quantity Lancashire and Cheshire are said to contain 5,546 millions of tons, and North Wales and Anglesey 2,010 millions.

In giving this estimate it is not definitely stated what deductions were made for probable loss in working, but as a deduction of 40 per cent. is made in another part of the Report, we may assume that it was made in this case, and I believe in valuing a coalfield it is usual to take about two thirds of the measured tons into account, so that the deduction is apparently a fair one.

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The Commissioners have estimated the coal at less depths than 4,000 feet, *underlying* the Permian formation at 56,273 millions of tons, making an aggregate total of 146,480 millions; and these latter are the figures they rely upon in calculating the actual coal supply of the United Kingdom. At the same time they hint at the possibility of our working at much greater depths, even to 6,000 feet—at which depth the natural temperature would be over 150° Fahr., and they estimated the coal between 4,000 and 6,000 feet at 29,000 millions of tons.

The question of coal being found under the cretaceous rocks in the South of England, and extending to the Bath and Bristol coalfields, was also considered, and the opinions of many eminent geologists were sought on the subject, but their views varied to such an extent that it was felt to be advisable to pass this question over. Sir Roderick Murchison, who was one of the Commissioners, on signing the Report, entered his protest against the assumption of the probability of a new coalfield in the South of England, on the ground that it was purely theoretical and contraverted by the evidence of physical data all around the area in question.

In fixing the depth of available coal at 4,000 feet, giving a natural temperature of 114° Fahrenheit, there seems to have been a good deal of speculation and difficulty in deciding whether or no a mine at such a depth could be sufficiently cooled down by ventilation to allow of work being carried on with any degree of success. However, the Commissioners eventually decided in the affirmative.

Having fixed the depth to which workings might be carried, and the coal available to that depth, they proceeded to seek a divisor by which to calculate the exhaustion of our coal-fields. Apparently, on the advice of Mr. Pryce Williams, it is sought to show that the consumption of coal

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in future years will bear a fixed relation to the increase of population, and many pages of the Report are devoted to elaborate calculations as to what that increase is likely to be, and the decision arrived at seems to be founded on the theory that the consumption of coal will be rather over 4½ tons per head of the population per annum (exclusive of coal exported), and on this assumption it is shown that 146,736 millions of tons, that is, the quantity they estimated as available, would be entirely exhausted in 360 years.

A second method of calculation by simply adding a constant quantity, viz., three million tons (which is co-equal with the average annual increase of production during the previous 14 years), to each following year's production, the Commissioners state that at the end of 100 years from 1871 the annual consumption would be 415 millions of tons, and from these data the coal would be exhausted in 276 years.

A third calculation is made on the assumption that the then population and consumption would remain constant, simply oscillating without advancing, and in that case the coal would last over 1,200 years. This view, however, was not considered of any importance, and it has certainly been amply disproved.

Of course, as the Commissioners pointed out, there are many other contingencies to be taken into account, the most important being the increasing cost and difficulty of working as the coal-fields draw near to a close—this they say will prolong their life to some extent by diminishing production.

I now propose to show to what extent the conclusions of the Commissioners have been verified up to the present time.

The calculation based upon population, and giving the duration at 360 years, is somewhat difficult to follow. The

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Report estimated that the population of Great Britain in 1881 would be 28,943,000, whereas the census for that year made it 29,710,012, and they fixed the home consumption of coal per head of the population per annum at 4·4266 tons, whereas it proved to be 4·7857 tons.

Since 1881 we have no means of knowing to what extent the population has increased, but the Commissioners estimated that in 1891 the population of Great Britain would be 31,955,000, and the home consumption of coal per head per annum would be 4·5786 tons.

Now if we divide this estimated population for the year 1891 into the production of 1888, which is 170,000,000, less the difference between the Commissioners' estimate of export (12 million tons) and the actual export (20 million tons), giving say 162,000,000 tons, we have a consumption of 5·0007 per head of the population against the 4·5786 estimated by the Commissioners, or a difference of nearly half a ton per head of population, that is, the consumption is estimated at nearly ten per cent. less for the year 1891 than it is found to be in the year 1888.

This being so, apparently we may deduct at least ten per cent. from the 360 years fixed upon by the Commissioners, which simply corrects the error at the end of 20 years, without taking into consideration the under-estimate over the whole period, which would be very considerable.

We will now,—and I think this the most important,—test the second system of calculation, from which the duration was fixed at 276 years, and which was arrived at by adding a constant quantity of three millions of tons to each year's production or consumption since 1869, in which year the coal raised amounted to 107 millions of tons. On this basis the production of 1888 works out to 164 millions of tons. And the actual statistics for 1888 show it to be 170 millions.

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I think the Commissioners may fairly be congratulated on this extraordinarily close estimate made nearly twenty years ago, the difference being only a little over 3 per cent.

The lapse of time and events have in this way certainly presented very strong evidence in favour of this latter method of calculation.

I find that if the average increase of the last ten years only be taken, that is from 1878 to 1888 instead of the fourteen years previous to 1869, the amount to be added would be about four millions of tons per annum.

On this basis the contents of the coalfields, viz., 146,736 millions of tons would be exhausted in 230 years from 1888.

Thus both systems seem to considerably over estimate the duration of the coal supply.

I have pointed out that the Commissioners based their Report on the assumption that seams of coal could be practically worked down to depths of 4,000 feet where the natural temperature would be 116° Fahrenheit. This temperature, calculated upon one degree for every 60 feet of depth, I have found by experiment to be under the mark and requires the addition of one degree for every 100 yards of depth, so that at 4,000 feet the temperature would actually be nearly 130° Fahrenheit.

TEMPERATURES TAKEN IN PLUGGED DRILL HOLES.

Name of Mine.	Theoretical Temperature due to depth.	Actual Temperature.	Depth in yards.
Douglas Bank (Arley Seam) ..	86°	91°	740
Abram (Arley Seam)	83°	89°	686
Ditto	87°	94°	758
Rosebridge (Arley Seam)	90°	93½°	806
*Ashton's Moss (4-feet Seam)..	100°	90°	1033
*Astley Deep Pit	95°	88°	951
Alexandra	87°	88°	755

* It is not clear whether the temperatures given in these cases were taken in the air at face or in drill holes.

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TEMPERATURE OF AIR IN FACE OF WORKINGS, THE WARMEST PLACES BEING SELECTED.

Name of Mine.	Temperature.	Depth from surface in yards.	Distance from down cast shaft.
Pemberton	81°	592	....
Abram	81°	758	750
Abram	84°	686 ...	1200
Dukinfield	86°	1056	Bottom of dip.
Alexandra	82°	755	Not stated.
Ashton's Moss....	86°	1019	Top of No. 2 level.
Dukinfield	87°	951	North Side Dip.
Douglas Bank ..	65°	740 . ..	160
Douglas Bank ..	68°	740	220
Douglas Bank ..	75°	750	390

The manager at one of the deep pits remarks that when men work in a temperature exceeding 86°, they have to pay higher wages.

I find that the natural temperature can be considerably reduced by ventilation. The Commissioners fixed the amount of this reduction at 7° where the air had to travel round a long wall face, but from experiments made when large volumes of air are passing, the natural temperature at the face is sometimes reduced as much as 15°. This still leaves us with a temperature of 115° at 4,000 feet depth. Now, I find that workmen begin to complain of heat when the temperature reaches about 80°, and I think that there is little hope of English workmen being able to do a fair day's work where the heat exceeds 90°. Personally, I find it distressingly hot in workings of 80°.

From this I think we may conclude that with our present knowledge and appliances (which, however, must by no means be considered finite), where temperature due to depth reaches 100°, coal cannot be worked except at very great expense, if at all.

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Now, as to the probability of the large amount of 56,273 millions of tons of coal being won from under the Permian and other formations, Mr. Dickinson, whom I have consulted as to the extent that this hope has been realised up to the present time, states: "I am not aware that to any extent since "the date of the Report any new light has been thrown on this "subject. There are, as you say, instances under the lip "of the over-lying formations where they thicken rapidly; "but there are other instances where they thicken slowly, "and these instances, so far as I have had opportunities of "judging, balance each other on the average, and are like "many coal basins which have a very slight dip at one side, "but are steep at the other."

My own opinion is that the New Red Sandstone thickens rapidly from its edge. At Bamfurlong Colliery, near Wigan, the sandstone is 26 yards thick at the Mains Pit, and in a borehole being put down 1¼ miles distant, it has already been proved 275 yards in thickness, and the hole is still in sandstone.

At Prescot some boreholes were put down, and the red rock was found to increase from 105 yards to 155 yards in a distance of 300 yards. In addition to the difficulty of depth in sinking, there is also the question of water, which is always found in very considerable quantities in passing through red sandstone.

On these grounds I consider that we may fairly discard the idea of any large amount of coal being available from this source, and with regard to the probability of coal under the cretaceous rocks in the South of England it seems hardly possible to conceive that the commercial enterprise of Englishmen could have failed to discover it long ago if it had been in existence.

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This being so I fix the available coal at 90,207 millions of tons, that is the quantity situated at less depths than 4,000 feet, allowing any additional quantities that may be got from under the red rock to stand as a set off against that which may be found impracticable on approaching 4,000 feet, and on this data if we add three million tons to each future years' production, this being the average increase since 1854 up to 1888 we get a life of 192 years, but the increase over the ten years previous to 1889 is four millions of tons, and assuming that the future increase will be equal to this we get a duration of 171 years only from the present time.

It will be interesting to us locally to glance for a moment at our own coalfields of Lancashire and Cheshire. The available coal at less depths than 4,000 feet in these counties is estimated by the Commissioners at 5,546 millions of tons after the necessary deductions for loss, in working, and the amount overlaid by the Permian within the depth mentioned is estimated at 6,085 millions of tons, but I only propose to deal with the former figures.

In 1888 the production of Lancashire and Cheshire reached twenty-two millions of tons, and assuming this quantity to remain constant the end would come in 234 years from 1888, but there has been an average increase during the last ten years of a quarter of a million tons, and if we use this as a constant number and add it to each future years' production we only get a duration of 137 years from 1879.

It is of course difficult to realise the immense increase of consumption which is shown at the end of a hundred years by the method of adding the constant number representing the average increase in past years, for instance a quarter of a million as computed for Lancashire and Cheshire shows that the production would be more than doubled at the end

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of that period. But I think the best criterion for dealing with a subject of this kind is the one adopted, viz., to found the estimate on what the experience of past years has proved rather than to set up some new theory of one's own evolved out of imaginary circumstances.

There is really nothing to prevent the expansion of trade necessary to this view, especially when we remember that during the ten years, for which the average increase is taken in one of the calculations, trade has been at its lowest ebb, and our exports of coal to foreign countries still only reaches about twenty millions of tons per annum.

There would appear to be an important outlet for English coal in this direction. It is true as telling against large exports, we have the fact that the home production of coal in many foreign countries is extending, but in no other country in the world is our own output surpassed.

The "Bulletin" published by the Ministry of Public Works in France, gives the production of the United States in 1887 at 118,000,000 tons, at a cost price at the pit mouth of 6s. 7d. per ton; Germany, 76,000,000 tons, at a cost price of 5s. per ton; France, 21,000,000 tons, at a cost of 8s. 6d. per ton; Austria, 19,000,000 tons, at a cost of 4s. 3d. a ton; Belgium, 18,000,000 tons, at a cost of 6s. 6d. a ton; Russia, 4,500,000 tons, the cost not stated; and Spain was the only other country in Europe which produced as much as a million tons; Australia produced 3,000,000 tons at a cost of 9s. a ton; India, 1,315,000 tons, at a cost of 10s. a ton; Japan, 1,254,000 tons, cost not stated; New Zealand, 543,000 tons, at a cost of 11s. a ton. The Orange State and Transvaal 20,400 tons at a cost of £2 15s. a ton.

These statistics give us an idea of the cost of production abroad, and this question of cost is the greatest obstacle in the way of expansion of trade—if foreign countries reduce their cost, while we at home add to ours, this obstacle

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becomes insurmountable. I find from particulars kindly furnished by the owners of different mines, that during the last twenty years the cost of getting English coal has not advanced very rapidly, the additional cost in 1889 being, apparently, about 9d. per ton more than 1869, the costs in 1869 and 1879 were very similar. This increase appears to be chiefly due to larger payments for labour, but whether to higher wages or to more labour being required by deeper mining, hardly affects the subject we have in hand.

As regards expansion of trade, consequent upon an increasing population, I think this is assured, and by no means depends upon what may happen in our own islands. We work for the world, and as the population of the world accumulates, so will the demand for that work increase. It has been stated that the whole of humanity at present existing on the globe could stand shoulder to shoulder in the smallest county in England.

Many may hold the view that miners will never be found in sufficient numbers to raise the large quantities of coal which these calculations imply, but I do not think this difficulty will be found very formidable. High wages will always attract workmen, and an increasing population will naturally compel larger numbers to seek their means of livelihood underground; indeed, it seems somewhat ridiculous to urge such a difficulty in the face of the present cry for emigration. It is true that the Government have adopted a somewhat protective policy in enacting that before a man can work alone as a miner, he must have served an apprenticeship of three years, but the word "alone" in the enactment referred to, removes the chief part of the hardship.

I venture to submit that hands and energy will readily be found to supply us with whatever increasing quantities of fuel our own industries or foreign countries may require, even to the extent of quadrupling the present demand. It

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is true that to obtain this result many more pits would have to be sunk and increased quantities drawn from existing workings, and it may be argued that the whole of the coalfield is now under lease and that such extension is impossible and an absurdity, but this same argument might have been used fifty years ago and probably was, and events have shown us with what truth. I think necessity will be found to be the mother of invention and an average increase over 34 years upon which the calculation in our case is founded can hardly be reasonably looked upon as an abnormal development, and we must bear in mind that only a steady increase from year to year is assumed extending over more than a hundred and fifty years, enough time for extraordinary developments of trade and commerce in every direction. The question of cost of production will be found to be the greatest difficulty in the way of the continued prosperity of the British coal industry.

There are several matters referred to in the Report which are very interesting to geologists. The Commissioners seem evidently to have been of opinion that coal has long ceased to grow, and that the seams exist chiefly on the site of the forest from which they were derived. Both these conclusions seem questionable. With regard to the latter the evidence appears to be that a coal seam on the site of the forest on which it grew, is the exception rather than the rule. The thin bands of rock or shale, frequently of not more than an inch or two in thickness, occurring in the body of a seam and extending with great regularity over large areas, and which could not afford foothold for a new growth, seem certainly to point to the accumulated vegetation having been moved by floods and deposited in quiet places, and that the thin bands of foreign matter were formed during the intervals between recurring floods.

It would be interesting to hear the views of geologists as

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to what became of the coal seams which disappeared upon the denudation of the upper parts of the coal formation previous to the Permian rocks being deposited, and which are found overlying to some extent; was this coal lost entirely or was it sifted and silted by water and deposited elsewhere?

I may mention that a piece of cannel was given to me a short time ago which had broken off and fallen from the Wigan 4 feet seam to a depth upwards of 250 yards down the Fault leader, the edges being as sharp as if it had been picked off yesterday. Can Geologists give us an idea of the date when the yawning fracture took place which allowed the piece of cannel to fall such a distance?

I hope some of the future papers that the Society may be favoured with may include some reference to these subjects.

Mr. JOHN KNOWLES, Ex-President of the Society proposed a vote of thanks to Mr. Hall for his address. He observed that the carefully prepared satistics which the President had brought under their notice deserved the fullest consideration.

Mr. DICKINSON said he had much pleasure in seconding the vote of thanks. He thought the review which the President had laid before them was a very able one. The Commissioners' report was a bulky volume, and Mr. Hall had picked out, he thought most of its salient points. But there were other points, of great importance, and it had sometime surprised him that those interested in the coal trade had not laid hold of some of the recommendations contained in the Report. It was too late in the afternoon to discuss them, but he thought they afforded material for some interesting discussions at future meetings.

The motion was put to the meeting by Mr. Knowles and carried unanimously.

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THE MEETING OF THE BRITISH ASSOCIATION AT NEWCASTLE-UPON-TYNE.

The Report of the Delegate, Mr. Mark Stirrup, F.G.S.

Mr. Stirrup read the following Report, which he had prepared as the Society's Delegate:—

It will be remembered that the institution of Corresponding Societies of the British Association arose out of a Report presented to the Council of that body, at the Southport meeting, 1883, by several gentlemen who took an interest in the operations of the local societies of our large towns, and who considered there was much valuable work accomplished, which was being wasted and forgotten, owing to the want of concentration and the need of greater publicity of the results obtained.

By union with a central controlling organization like that of the British Association, it was thought that the various scientific societies scattered through the land, could, when necessary, be made exceedingly useful in collecting any desirable information, or in aiding any plan of scientific research.

Especially, was it thought that important and valuable aid could be given by local societies to those annually appointed committees of the British Association, which are formed for the carrying out of such investigations as those on the rainfall, the temperature of rivers and lakes, underground temperature, erosion of sea coasts, the height of underground waters, the distribution of erratic blocks, pre-historic remains, the migration of birds, the preservation

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of native plants, and various enquiries in other branches of science.

This alliance was eventually accepted by the Council, and the "Corresponding Societies" Committee has since become an integrant part of the machinery of the Association.

It then remained to the local societies to organise among themselves, the means by which their usefulness should be extended, as indicated in the original report. A year or two of indecisive and tentative efforts followed, but now several of the societies are actively engaged, either in union or separately, in aiding those research committees of the Association which have been already for some years in operation.

The advantage of co-operation in work of the character undertaken by these scientific committees is self-evident, and the local society, and each contributing member thereof, has the benefit of recognition by the publicity given to their papers in the Annual Report of the Corresponding Societies Committee, which report is incorporated in the annual volume published by the Association. As a means of bringing the societies, whose fields of operation are so widely separated, into communication, each Corresponding Society is invited to send a delegate to the annual meeting of the British Association wherever that may be fixed; at such meeting the delegates constitute a conference, of which two are held, at both of which the delegate is expected to be present. At these conferences the several sections of the Association are represented by deputies, and matters are discussed in which the co-operation of the Corresponding Societies is desired, and, also, enquiries are answered, and reports made, where thought necessary, as to any special work in which a corresponding society may be engaged, or in which it may desire to embark. Such reports or recom-

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mendations brought before the conference the delegates are requested to lay before their respective societies, so that members, where able, may offer assistance. I have gone thus somewhat fully into the history of this movement, so that the members may grasp its importance, and may be induced, wherever possible, to lend their aid.

At the recent meeting in Newcastle-upon-Tyne, in September last, some 35 delegates, representing societies in various parts of the United Kingdom were present.

At the first conference under the presidency of Mr. Francis Galton, F.R.S., some questions relating to archæological subjects were discussed, but these being outside the scope of our Society's work, I need not further allude to them. The Rev. E. P. Knubley reported on behalf of the Yorkshire Naturalists' Union, which is a federation of several Naturalist Societies, that active interest had been aroused in the question of the distribution of erratic boulders over the districts with which they were connected, which had resulted in no less than 50 reports having been submitted to the Boulder Committee. Another subject upon which they were working was the fossil flora of Yorkshire, which included that of their coal-fields.

A proposal which was first made at the Bath Meeting by Mr. O. W. Jeffs, was again brought forward, to recommend the formation of a committee to collect and register photographs of geological interest.

The suggestion was referred back to the consideration of the committee of Section C., where it was afterwards adopted and sent up to the Commmitte of Recommendations who apportioned a grant of £10 for the purpose.

A number of photographs which had been sent in by several of the Corresponding Societies were exhibited

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at one of the conversaziones held in the Newcastle Museum.

Professor Lebour spoke of the work of the Earth Tremor Committee and some experiments which were being made by the North of England Institute of Mining Engineers. Two seismometers or earthquake recorders being placed underground, in one of the coal-pit workings and two on the surface, so that for the first time, the observations would be taken simultaneously. The readings were automatic and continuous.

The second conference was presided over by Mr. William Topley, F.R.S., when further reports were made, Dr. Mills drawing attention to the work of the committee on the surface temperature of rivers, lakes, and estuaries, and urging the delegates to use their influence with their respective societies to increase the number of observers.

Mr. De Rance, F.G.S., Honorary Secretary of the Underground Water Committee deputed by Section C., spoke of the importance of the enquiry into the water of the New Red Sandstone and Permian formations as a source of water supply to towns, and recommended the subject to the attention of provincial societies whose members might often aid in collecting the particulars of any well borings in their neighbourhood.

The Reports of the Erratic Blocks and Boulders Committee and the Coast Erosion Committee were also noticed.

Professor Lebour, Secretary to the North of England Institute of Mining Engineers, speaking of the work of the Institute said they had formed a committee, now in full working order, to report on the subject of flameless explosives as used in collieries. Their work he said was a philanthrophic

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one, as they wished to avoid the possibility of a flame being projected from a blown-out shot, in an atmosphere laden with flying particles of dust.

He also referred to another committee, consisting of the members of the Mining Institute of the North of England, of the Midlands, and of South Wales, which was appointed for the purpose of carrying out a series of experiments with fans for artificial ventilation.

Such were the main topics of interest to our Society, which were brought before the two conferences, and which it is the duty of your delegate to report and bring before you.

With regard to our own work, we have had some three or four papers on erratic blocks brought before the Society, the results of which have been forwarded to the British Association Committee, and incorporated in their Report.

Our Society has been instrumental also in assisting the newly formed committee for the investigation of the temperature variation in lakes, rivers, and estuaries. Our industrious and valuable member, Mr. Watts, has submitted a careful set of thermometrical observations made at the reservoirs belonging to the Oldham Corporation Waterworks, and the Manchester Waterworks Committee, through Mr. Berry, have consented to furnish similar details with regard to those large artificial lakes known as the Woodhead Reservoirs.

Owing to the recent formation of this committee, and the short time that has elapsed since the commencement of observations, for the most part early in the present year, no discussion of the results was undertaken at the Newcastle meeting, but it is confidently expected that these observations, when taken in connection with the temperature and rainfall of the respective districts, will lead to results both

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interesting and valuable; for instance, investigations have already shown that while in some rivers the temperature was increased by the rainfall, in other rivers the opposite condition obtained.

Several other of these Research Committees might, I feel sure, be aided by some of the members, if they will only try and make use of the opportunities which must occasionally present themselves. For example, borings for water are interesting and valuable, not only for the analyses of the waters obtained, but also for the characters of the beds passed through; the effect of rainfall upon these underground supplies is also well worth studying and registering.

Then there are the questions of underground temperature, and those imperceptible vibrations of the earth's surface called earth tremors, both of which subjects seem naturally to come within the scope of the Society's work. Notes on any of these topics would form suitable and welcome communications to the Society, the results of which would afterwards be forwarded to the respective committees of the Association for arrangement and comparison.

Although my report as delegate would naturally conclude with these references to the doings of the Corresponding Societies' Committee, I may perhaps be expected to say something as to the matters discussed in the section devoted to geology.

My remarks will be brief, as but few of the papers brought before the Section need specially be alluded to, many being devoted to somewhat technical subjects, and only interesting to specialists.

The Section, as you know, was presided over by Professor James Geikie, F.R.S., the well known glacialist and author of the "Great Ice Age," who, in his presidential address, gave a resumé of the facts obtained by the most recent

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workers in the domain of glacial geology, both British and Continental. He confirmed and maintained his views that the drift deposits of our island and the continent are not iceberg droppings, as averred by some geologists, but are the result of the action of inland or land ice.

He said "that the notion of a general ice sheet having covered a large part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral area of the great northern drift." It was probably owing to the presence of so eminent an authority on glacial phenomena that the Section had the treat of hearing our townsman, Mr. H. H. Howorth, M.P., dilate on the glacial theories of Agassiz and other extreme glacialists, whose arguments and theories with regard to a Polar ice-cap or former great ice sheet, extending over a large part of the northern hemisphere, Mr: Howorth combatted with his usual energy and offered evidence in opposition, which he pronounced overwhelming.

Other papers perhaps of more practical interest, were those on the Cleveland and Durham Salt Industry, the Gold Fields of South Africa, and the several reports presented by the Research Committees.

The area of the salt deposit in the neighbourhood of the Tees appears to be restricted according to the results of recent borings to a district of some twenty square miles in extent. The recent boring at Seaton Carew, of which you have had the details previously brought before you, proved to be outside the salt basin. The exact position in the rocks of these salt beds gave rise to some little difference of opinion.

Professor Hull stated that this was the only district in the British Isles, in which there were two distinct geological

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horizons for salt rock, meaning, I presume, the Keuper division of the Trias and the Permian.

"Middlesborough salt rock, he said was found in the upper division of the Triassic group, which was the division in which the salt rock of Cheshire, Worcestershire, Warwickshire, Leicestershire, and all other salt-bearing shires was to be found."

Mr. De Rance, on the other hand, said the salt mesures of the Middlesborough area, were all in one horizon, and of *Permian* age.

The boring at Seaton Carew, though missing the salt beds, gave rise to some hopes that the coal measures had been struck, but this much to be desired result owing to the stoppage of the boring, has not yet been proved. Professor Hull, in the discussion of this paper, spoke as to the speculation which was rife, as to the existence of a concealed coal-field between the southern extremity of the Newcastle district, and the northern extremity of the Yorkshire coal field, and said that he had seen no reason yet to depart from the conclusion which he had formerly come to,—that there was no concealed coal field existing in the district in question.

An interesting paper, on the Gold Fields of the district of Johannesburg, South Africa, which are at present exciting so much attention, was given by Mr. E. B. Dorsey, a practical mining engineer, who had visited South Africa professionally. He describes the geological formation whence the gold is derived as consisting of a series of strata of sandstone, quartzite, slate and conglomerate, all evidently deposited quietly by water.

It is in the beds of conglomerate, composed of quartz, quartzite and sandstone pebbles, that the particles of gold are found, but curiously enough the gold shows no sign of

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being water-worn like the material of which the stratum is composed. As yet no fossils have been discovered from which the geological age of the formation can be ascertained. Another singular circumstance which Mr Dorsey mentions with regard to these gold bearing rocks, is that they form a basin shaped area like that of most coal basins, and that an inferior quality of coal is actually found within 200 yards of workings, on the MAIN REEF, which produce good gold ore; and he says, that it is very likely that ore containing gold, and coal for fuel to crush it, will yet come from the same shaft.

The reported richness of the mines on the Main Reef of the Johannesburg district is fully borne out by the evidence adduced, and they are said to be the most remarkable and the richest continuous series of gold mines in the world.

I have selected these few papers out of the many brought before Section C, as of more general interest to our members, but I, perhaps, ought not to close my Report without some reference to Professor Hull's paper on "Our Coal Resources," which was read before Section F (Economic Science and Statistics), wherein he dealt with the output of British mines from the commencement of the century.

The Professor said, there was reason for believing that, between the beginning of the century and the year 1875 the output of coal had more than doubled itself for each successive quarter of a century. Since the year 1860, in which he had estimated that sufficient coal existed to a limiting depth of 4,000 feet, to last, at the *rate of production for that year*, for 1,000 years; the available quantity of coal had been reduced by 3,650,000,000 tons; but this amount, great as it was, had not very materially affected our coal resources. After considering the relation between coal production and the development of the iron trade, the Professor concluded

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his remarks by expressing an opinion that, while the enormous output of coal during the past few years had not actually crippled our resources, yet a general rise in the value of coal must ensue in the near future, owing to the great depth at which the mines will have to be worked, and the increased cost of coal-mining. Referring especially to the Northumberland and Durham coal-field, Professor Hull said there was no sign of its falling off, despite the length of time it had been worked.

He calculated that the supply of this field, at the present rate of consumption would last 300 years.

For fear of unduly lengthening this Report, I have restricted my remarks to a few only of the interesting papers that might have been mentioned, selecting those whose subject matter was in relation with our own line of work.

My main object in presenting this Report is to show my fellow members how vast the field is in which help is wanted, and where useful work may be done; and, in conclusion, would urge upon each individual member to ask himself what personal assistance he can offer in any of the scientific investigations now being carried on by the committees of the British Association.

The range of subjects is a wide one, some of which could be materially aided without much effort on the part of members—such as those pertaining to the water supply, temperature observations underground and on the surface, both of land and water, distribution of erratic blocks, the fossil flora of the coal measures, the collection of the photographs of interesting geological phenomena, earth tremors, &c., &c.

Considering coal-pits as storehouses of geological facts, there is one investigation I would strongly recommend for your consideration, a work which seems specially to fall

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within our province, and which I should like to see taken up as the Society's work, and that is a thorough examination of the fossil fauna and flora of the coal measures of our district, tabulating the fossils carefully bed by bed, noting the abundant species as well as the rarer ones, and marking any that are typical of special horizons.

This is a work that has long been wanted doing for our British coal-fields and in which we have been distanced by continental geologists.

The access to such detailed information would be not only valuable to the geologist, but would often be of incalculable benefit to the owners and lessees of coal mines, as it would probably enable them when opening new mines, to fix their horizon and identify the beds passed through, by the character of the fossils met with.

To our foreign visitors, evidence such as I have indicated would not only be precious but actually necessary for the correlation of widely separated coal-fields and for the correct estimation of their relative age.

England had the honour of the visit of several eminent foreign geologists last year at the International Geological Congress held in London; one of whom, Herr D. Stur, the Director of the Geological Survey of Austria, took the opportunity of visiting some of our English coal-fields and some of the principal museums, one of the latter being our Manchester Museum at Owens College.

He has since in a paper published in "*Jahrbuch der K. K. Geolog. Reichsanstalt, 1889,*" embodied his views on the British coal plants and the relative age of our different coal fields, as compared with continental ones, especially those of the Moravian, Bohemian, and Silesian areas; but one cannot but think that the materials at his disposal must

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have been too meagre to warrant any correct or definite conclusions, when one is aware of the non-existence of the data, from which only reliable deductions can be drawn.

Mr. De Rance said he should like to move a vote of thanks to his friend Mr. Stirrup for his report. Being a member of three investigation committees of the British Association, and the Secretary of two of them, he felt sure that all of them were very much obliged to Mr. Stirrup for the care and consideration with which he had worked that report out. It was his (Mr. De Rance's) privilege to hear the papers read of which the Honorary Secretary had given them an abstract, and really one almost felt it was hardly necessary to have all the trouble and care of attending the meetings of the British Association in person—when one could have a *précis* put before one in half an hour in the admirable way that Mr. Stirrup had done. A fortnight ago, he (Mr. De Rance) was present at the Annual Meeting of the Yorkshire Polytechnic and West Riding Geological Society, and had the good fortune to hear an exceedingly good address from the President, the Marquis of Ripon, which address was framed almost exactly on the same lines as Mr. Stirrup's report: he set forth the great value of the work that might be done by the members of provincial societies who had opportunities of noting local phenomena and working one with another; and they alone could give that accuracy of detail, arising from intimate knowledge of local matters, which nobody however eminent or industrious who came down for a short time could ever hope to attain. As regarded the Underground Water Committee there was one trifling error which he would like to mention. Mr. Stirrup, in giving the title of that committee, gave it as it was in 1874, when the committee was constituted at the Belfast meeting "to inquire into the

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waters of the New Red Sandstone and Permian." In subsequent years the scope of the inquiry was enlarged by the Council of the Association, and it was made to include the cretaceous and other beds, and now their function was to inquire into the waters of all the "pervious rocks of England and Wales." It therefore included the millstone-grit and coal-measures, and he need not say how thankful the committee of inquiry would be for information as to the quantity or quality of water in those formations, or indeed any formation. One of the queries they circulated was: "Have any brine springs or brackish waters been met with?" Into that matter he would not then enter, further than to remind the Society that two years ago he laid before them the results which had been obtained up to that date, showing that brine did occur very frequently in the coal measures of this country. Information on these points would be exceedingly valuable, because they not only wanted to know where they should sink for fresh water, but also they wanted to know where not to sink, so that they might not, after much expense, get something they did not want. One piece of information which he heard that morning bore on the salt question in the Middlesborough district; to the effect that the boring on the preceding day reached the rock salt, at a point the most easterly of any borings in that district. In that boring between Redcar and Middlesborough, they passed through the Lias and the whole series of underlying beds, and came upon the rock salt at a depth of more than 1,600 feet.

He moved that a vote of thanks be given to their laborious Secretary, Mr. Stirrup, for the very valuable report he had laid before them.

The motion was seconded and passed unanimously.

This concluded the business of the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XX. SESSION 1889-90.

The ORDINARY MEETING of the Members was held on Tuesday, December 10th, 1889, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, HENRY HALL, Esq., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

CHARLES H. HIGSON, Mining Engineer, The Park Collieries, Wigan.

JOHN ROBINSON, Mining Engineer, Haydock Collieries, St. Helens.

JAMES HACKING, Bolton Road, Darwen.

JOHN ILES, 39, Albert Road, Blackpool.

ROWLAND GASCOYNE, 11, Trafalgar Square, Ashton-under-Lyne.

Mr. MARK STIRRUP (Honorary Secretary) reported that he had received from M. Brongniart, of Paris (an Honorary Member of the Society), a valuable monograph on the Fossil Fishes of the Commentry Mine, near St. Etienne, which M. Brongniart asked him to present to the Society in his name. He had also the pleasure to present on behalf of

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the author, M. E. A. Martel, several publications on the Region of the Causses and their subterranean waters, in the departments of Lozère and Aveyron, Southern France.

The thanks of the Society were voted to the respective donors.

The following are the recent additions to the Library :—

Belfast Natural History and Philosophical Society: Report and Proceedings for Session 1888-9.—*From the Society.*

Chesterfield and Midland Counties Institute of Engineers: Transactions, Part 5, Vol. XVII.—*From the Institute.*

Cornwall, Royal Institution of: Journal, Part 4, Vol. IX.—*From the Council.*

Essex Naturalist: Nos. 1-9, Vol. III., 1889.—*From the Essex Field Club.*

Leicester Literary and Philosophical Society: Transactions, Part 12, 1889, Part 1, Vol. II.—*From the Society.*

Liverpool Geological Society: Proceedings, Part 1, Vol. VI.—*From the Society.*

——— Science Students' Association: Proceedings and Report, 1888-9.—*From the Association.*

London Geological Society: Quarterly Journal, Nos. 179-180, Vol. XLV. List of Geological Society of London, November, 1889.—*From the Society.*

——— Geologists' Association: Proceedings, Nos. 4-5, Vol. XI.—*From the Association.*

——— Geological Magazine: Nos. 303-6, Vol. VI., 1889.—*Purchased.*

——— Institute of Mechanical Engineers: Proceedings, No. 2, 1889.—*From the Institute.*

——— Iron and Steel Institute: Journal, No. 1, 1889.—*From the Institute.*

——— Royal Society: Proceedings, Parts 282-283, Vol. XLVI.—*From the Society.*

Manchester Association of Engineers: Two Pamphlets.—*From the Association.*

——— Microscopical Society: Annual Report, 1888.—*From the Society.*

Midland Institute of Engineers: Transactions, Part 104, Vol. XII.—*From the Council.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Part 3, Vol. XXXVIII.—*From the Institute.*

Scotland, Mining Institute of Scotland: Transactions, Parts 4-6, Vol. XI. Report of Committee on Coal Cleaning, 1889.—*From the Council.*

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Southampton, Hampshire Field Club: Papers and Proceedings, No. 3, 1889.—*From the Club.*

South Wales Institute of Engineers: Proceedings, Part 4, Vol. XVI.—*From the Institute.*

Warwickshire Naturalists' Field Club: Proceedings, 1888.—*From the Club.*

List of Mines worked, 1888; List of Plans of abandoned Mines, 1889; Mineral Statistics of the United Kingdom for year 1888: Report of Joseph Dickinson, Esq., for year 1888, Manchester District.—*Presented by Joseph Dickinson, Esq.*

Report of Mine Inspector, South Western District, 1888. By J. S. Martin, Esq.—*From the Author.*

Irish Marbles and Limestones. Pamphlet by G. H. Kinahan.—*From the Author.*

Probable Cause of the Displacement of Beach Lines. Second Note. By A. Blytt. Pamphlet.—*From the Author.*

Note on Glacial Geology of Loch Sween, Argyllshire. By H. W. Crosskey, LL.D., F.G.S. Pamphlet.—*From the Author.*

Owens College Calendar, Session 1889-90.

Public Libraries and Museum of Bradford: Nineteenth Annual Report, 1889.

Organization of the Fossil Plants of the Coal Measures. Part 16. By Prof. W. C. Williamson.—*Presented by the Author.*

Faune Ichthyologique des Mines de Houille de Commentry. Part 1. By Chas. Brongniart, F.E.S.—*Presented by the Author.*

Sous Terre—Auvergne et Cevennes—Les Aiguilles du Gouter et d'Argentière.—La Région des Causses—Sous Terre et sur Mer—Deux Ascensions dans le Massif du Mont Blanc. 3 Extraits du Bulletin de la Soc. Géol. de France.—4 Extraits des Comptes Rendus de l'Acad. des Sciences. Région des Causses (Soc. de Topog.)—*Sundry Pamphlets presented by the Author, E. A. Martel, per M. Stirrup.*

Salt Making Processes in the United States. By Thos. M. Chatard. Urao. By T. M. Chatard. The Determination of Water and Carbonic Acid in Natural and Artificial Salts. By T. M. Chatard. Analyses of Waters of American Alkali Lakes. By T. M. Chatard. Notes on Vale of Clwyd Caves. By C. E. de Rance. Age of the Clwydian Caves. By C. E. de Rance. Fifteenth Roport of Underground Water Committee. By C. E. de Rance.—*Presented by C. E. de Rance.*

Geological Survey Memoir,			Burnley District.	*Purchased.*
,,	,,	,,	Blackpool District.	,,
,,	,,	,,	Bradford and Skipton.	,,

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Geological Survey Memoir, Bridlington Bay. *Purchased.*
" " " Chester. "
" " " Cleveland (North). "
" " " Derbyshire (North). "
" " " Driffield. "
" " " Eskdale, Rosedale. "
" " " Kendal, Sedbergh, &c. "
" " " Lake District (North). "
" " " Malton (96 S.E.) "
" " " Northallerton and Thirsk. "
" " " Nottingham (2nd Edition). "
" " " Nottingham & Derbyshire. "
" " " Nottingham, Yorkshire, and Derbyshire. "
" " " Prescot, Lancashire (3rd Edition). "
" " " Scarborough. "
" " " Whitby and Scarborough. "
" " " York and Hull. "
" " " York and South of Malton. "
" " " Holderness. "

Geology of London. 2 Vols. By W. Whitaker, F.G.S.—*Purchased.*

Middle Lias of Northamptonshire. By Beeby Thompson, F.G.S.—*Purchased.*

The Bermuda Islands. By Angelo Heilprin.—*Purchased.*

Canada, Ottawa, The Canadian Mining Review, Nos. 8-11, Vol. VIII.—*From the Editor.*

——— Montreal, New Species of Fossil Sponges. By Sir J. W. Dawson, LL.D., &c.—*From the Author.*

——— On Fossil Plants from Mackenzie and Bow Rivers. By Sir J. W. Dawson, LL.D., &c.—*From the Author.*

——— Geological and Natural History Survey of Canada: Contributions to Canadian Palæontology, Vol. I. By J. F. Whiteaves, F.G.S.—*From A. R. C. Selwyn, F.R.S., Director of the Survey.*

U.S.A., Chapel Hill, North Carolina: Elisha Mitchell Scientific Society Part 1, Vol. VI.—*From the Society.*

——— Harvard College: Bulletin of the Museum of Comparative Zoology, Nos. 4-5, Vol. XVII.—*From Alexander Agassiz.*

——— New York, American Institute of Mining Engineers: Transactions, Vol. XVII.—*From the Institute.*

——— Philadelphia, Academy of Natural Sciences: Proceedings, Part 1, 1889.—*From the Academy.*

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U.S.A., Philadelphia, Journal of Franklin Institute: Nos. 765-768, Vol. CXXVIII.—*From the Institute.*

——— Scranton, Pa., The Colliery Engineer: Nos. 2-5, Vol. X.—*From the Editor.*

India, Calcutta, Records of the Geological Survey of India: Part 3, Vol. XXII.—*From the Government.*

Melbourne, Geological Society of Australasia: Transactions, Part 4, Vol. I.—*From the Society.*

Sydney, New South Wales, Department of Mines: Annual Report, 1888.—*From the Government.*

——— Geological Survey of New South Wales: Records, Vol. I., Part 2, 1889.

——— Report of Trustees of Australian Museum, 1888.—New South Wales, 1889. Reports on Mining Machinery and Treatment of Ores.—*From the Hon. the Minister of Mines.*

Victoria, Gold Fields of: Reports of Mining Registrars, March, 1889, June, 1889.—*From the Government.*

——— Mineral Statistics of: for year 1888.—*From the Government.*

——— Natural History of: Prodromus of the Zoology, 1889. Decades 18-19.—*From Fred. Mc.Coy, F.R.S.*

New Zealand: Report of the Mining Industry, 1889.—*From the Government.*

Berlin, Zeitschrift der Deutschen Geologischen Gesellschaft: Heft 1-2, Band XLI.—*From the Society.*

——— Verhandlungen der Gesellschaft für Erdkunde: No. 9, Band XVI.—*From the Society.*

Brussels, Société Malacologique de Belgique: Annales, Vol. XXIII., 1888. Procès-Verbaux, July, 1888, to July, 1889.—*From the Society.*

Buenos Ayres, Datos Trimestrales del Comercio Exterior: No. 62, 1889. Estadistica del Comercio e Navigacion de Republica Argentina, 1889. Censo Municipal de Buenos Aires for year 1887.—*From the Government.*

Christiania, Royal University of Norway: Lakis Kratere og Lavastromme. By Amund Helland.—*From the University.*

Halle, a/s, Vereins fur Erdkunde: Mittheilungen, 1889.—*From the Society.*

Kazan, Russia, Society of Naturalists of the University of Kazan: Publications, Parts 1-3 and 5, Vol. XIX.—*From the Society.*

Lille, Société Géologique du Nord: Annales XV., 1887-8.—*From the Society.*

Naples, Accademia della Scienze Fisiche e Matematiche: Rendiconti, Fasc 11-12, Vol. II., Series 2; Fasc 1-6, Vol. III., Series 2.—*From the Academy.*

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Paris, Revue de le Legislation des Mines: July-August, September-October, 1889.—*Purchased.*

Roma, Atti della Reale Accademia dei Lincei: Rendiconti, Fasc. 9-12, Vol. V.; Fasc. 1-6, Vol. V., 1889. *From the Academy.*

St. Petersbourg, Institut des Mines, Comité Géologique: Mémoires, Vol. III., No. 4. Allegemeine Geologische Karte von Russland: Blatt 139, 1889. Vol. VIII., No. 1, 1888. Bulletins: Nos. 6-10, Vol. VII.; Nos. 1-5, Vol. VIII.; Supplement, Vol. VIII., 1889.—*From the Minister of Domains.*

Stockholm, Royal Swedish Academy of Sciences: Publications, Section 2. Mineralogy and Geognosy, Vols. XII-XIII.—*From the Academy.*

ALLEGED RECENT DISCOVERY OF A FOSSIL FOREST IN SCOTLAND.

By Mr. Mark Stirrup, F.G.S.

About two months ago the following paragraph went the round of some of the newspapers:—

"A Fossil Forest in Scotland.—A 'fossil forest' has been discovered in the Muirhouse Pit, about half a mile to the East of Tranent, in Scotland. Thirty or forty fossil trunks have already been laid bare, some of them with their roots entire, others broken across. They are found in the 'blaes' a layer of hard clay between the top of the coal seam, and the solid stone roof of the galleries. Most of the specimens are of grey freestone, but a few are composed of 'blaes' and freestone in alternate layers. One of the trunks unearthed is at least two feet in diameter. How far the ancient forest extends is as yet unknown."

As doubts are still expressed by scientific men both at home and abroad as to the existence *in sitû* (on the spot where they originally grew) of trees of carboniferous age, I took the opportunity, while in Edinburgh last month, of finding out the colliery referred to. The Tranent collieries lie 10 to 12 miles east of Edinburgh, in Haddingtonshire, the nearest railway station being Prestonpans. The Muirpark pit, where the fossils were found, lies a little outside of the town of Tranent.

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The pit is not a deep one, about 65 fathoms in depth. Two seams of coal occur, one 8 inch, the other 4 feet thick, the latter only being worked, being underlaid by a stratum of sand—or free-stone. A bed of hard clay (fire-clay) ranging in places from 10 inches to 8 feet thick, separates the two seams.

Thin lenticular beds of fine sandstone are also seen from time to time intercalated in the clay bed.

It is in the side walls of the galleries connecting the different parts of the mine, and in the clay bed before mentioned, that the so-called fossil forest has been disclosed.

The fossil forest, however, turns out to be no fossil forest at all, and the statement in the newspapers that some of the fossil trunks were laid bare *with their roots entire, others broken across,* is entirely misleading and incorrect.

In none of the several parts of the workings that I visited, where these fossil trees occur, was there any portion of the trunks seen attached to their roots; moreover, the overlooker or underground manager who accompanied me, said that he had never seen a single instance of these stems connected with the roots, so as to suggest that they might have grown on the spot.

What you may see as you pass along the workings, are portions or fragments of numerous casts of fossil stems in the walls of the galleries, embedded in the stratum of hard dark coloured clay before mentioned.

Curiously enough, these are for the most part seen to be standing erect, that is to say at right angles to the plane of stratification, not planted closely together, but widely dispersed over the area that is being mined.

These casts have preserved the original rotundity of the trunk, owing to having been filled in with fine sand, similar in character to that which forms the material of the free-stone bands which occur in the neighbouring measures.

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The thickest of these stems is not more than 20 inches in transverse diameter, and the longest of them does not measure more than 2½ feet in height.

That these fossils are only fragments of tree trunks, and are not prolonged upwards into the roof nor downwards into the floor of the mine, is a fact readily demonstrated, as the termination in the surrounding matrix of both the upper and lower ends is distinctly visible, and in some cases the superior extremity is partially uncovered, showing the kind of material by which the hollow stem has been filled. No traces of roots could be seen in the impure coal or shaley layer, which in some cases underlies these casts. Whether these fossils are the remains of Sigillarian or Lepidodendroid trees seems difficult to determine, seeing that the external markings are extremely indistinct; the thin coating of coal which often surrounds these stems being in many cases entirely absent.

What markings could be made out, either on the cast or the mould, seemed to be Lepidodendroid in character.

That these fossil trees were not in the place where they originally grew seems abundantly proved from the facts which I have stated, yet, that they could have drifted from afar, seems also doubtful, seeing that the fractured stems presented clean broken edges, and showed few signs of abrasion by rolling. The evidence then points to growth at no great distance from the present site. As the trees were in process of decay, they were probably periodically overwhelmed with waters heavily charged with sandy sediment, which gradually filled the hollow trunk, and became firm and consolidated within the external vegetable sheath.

As time progressed, this vegetable sheath would itself decay, leaving only internal casts as memorials of these ancient monarchs of the forest.

Facts, such as I have brought before you, are, I am aware, neither singular nor new, as many of our Lancashire collieries

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could give similar evidence with regard to fossil trees, but when these Tranent fossils have been so publicly stated to be another example of a Fossil Forest *in sitû*, I thought it desirable to give the result of my visit to the locality.

Notwithstanding the exclusion of this instance, Scotland probably still possesses, in what has been called the "Fossil Grove," at Whiteinch, near Glasgow, the finest example of fossil trees *in sitû* of Carboniferous age that Great Britain at present can show.

Lancashire at one time had that pre-eminence in the large fossil trees that were exposed in 1839 near Dixon Fold Station, on the Manchester and Bolton Railway, during the making of the line. A full description of the characters of these trees was given by Dr. Bowman, in the first volume of the Manchester Geological Society's Transactions; these specimens, however, though partially protected from the weather, have since suffered much from abrasion and natural delapidation and decay.

The discovery of the "Fossil Grove," near Glasgow, was made in the early part of last year, during the laying out of some land at Whiteinch, which had been obtained for the purposes of a public park.

During excavations of an old quarry which formed part of the land, nine perfectly rooted trees with erect stems were uncovered, and these all standing in a space measuring 64 feet by 25 feet.

They have been described by Messrs. Young and Glen, in a paper read before the Geological Society of Glasgow, in April, 1888, which is printed in their Transactions.

I was glad to find, on my recent visit, that the Park authorities were taking the praiseworthy precaution of erecting a substantial building over these fossil stems, thereby protecting these interesting relics of palæozoic vegetation from exposure to the weather and consequent injury and destruction.

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Mr. WILD: It strikes me that probably a little closer observation of the base of these trunks would have disclosed roots, and divisions of roots, or rootlets in the shale. I have found, in those we have had bared at Bardsley, that we could hardly discover the swelling out of the four primary divisions, but that looking carefully it could be seen that they were pressed into a thin film, with stigmatic punctures, trailing away right into the roof. The reason probably is that they have gradually been forced down by the superincumbent pressure, and having been broken off at the bottom of the trunk the extended roots cannot be found unless the roof is examined very carefully. I find these rootlets have not been filled in with the same material as the trunk; these are merely films of bark, showing punctures above and below—more distinctly above—and I think, in the case mentioned by Mr. Stirrup, careful examination would have shown the same thing to exist.

Mr. STIRRUP: There is this fact, Mr. Wild seems not to have noted, that we could see the bottom of the fragment of the trunk, as well as the top—and we could see its whole extent in the clay bed—there was no continuation upwards or downwards, no swelling out into roots whatever. In the roof of the mine were evident signs of drift in the horizontal and varying position and direction of other fossil stems apparently Lepidodendroid in character, and from 6 to 8 feet in length, but these were all crushed and flattened.

Mr. WILD: I remember at the Ashton Moss Colliery seeing several trunks which were just swelling out at the base, showing a connection with the thin filaments of coal—swelling out and then flattening—but the rest seemed to be cut off nearly level, but just in the same horizon. This, I think, must have been owing to some difference in the decay of the roots, for they are cut off at the bottom at right angles to the stem.

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ON THE PROBABLE AVERAGE DEPTH AT WHICH COAL IS NOW BEING WORKED IN THE BRITISH ISLES.

By Prof. Edward Hull, LL.D., F.R.S., Director of the Geological Survey of Ireland.

(Communicated by Mr. Joseph Dickinson, F.G.S.)

In connection with the question of the progress of exhaustion of our coalfields, there is a point of much interest which could only be successfully dealt with by the co-operation of mining engineers well acquainted with the different districts where coal is being worked. I refer to the question of the average depth at which coal is being extracted, and the rate at which that average is increasing during successive intervals of say twenty or twenty-five years.

With the information now in my possession I cannot pretend to offer more than a very general answer to the question of the average depth, and it is tolerably certain that even between our largest and most important coal-fields there may be considerable differences in the average depth of coal-produce in each.

The question is not to be solved by taking the depths of the deepest and of the shallowest pits, and taking the mean proportional between them; for we must recollect that the rate of out-put from shallow pits will generally be very much slower than from deep pits; as, owing to the great primary cost of the latter, they can only be made to yield a profit after a large quantity of coal has been raised and disposed of; while, on the other hand, a comparatively small out-put will suffice to keep a shallow colliery alive. For the above reason an estimate could be more nearly arrived at by supposing the average depth to be somewhat greater than that between the shallowest and the deepest pits.

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If we suppose that at the time of the introduction of the steam engine into coal mining, about the year 1820, the average depth did not exceed *(q.p.)* one hundred yards, owing to the necessity of employing horse power for winding and pumping and if we were to assume the average depth at the present day to be 350-400 yards (probably a near approximation) we should be able to determine the rate of increase of average depth during the last 65 or 70 years. Supposing the rate to have been uniform (which it unquestionably was not) the increase of the average depth would have been at the rate of 4½ yards per annum, or 90 yards in 20 years. But the rate of increase ought to be represented, not by a straight line, but by a curve corresponding in some degree to that which represents the progressive rate of coal production from the beginning of the century to the present time.

The fact that more than one seam of coal is worked in a coal-district somewhat complicates the problem here presented, and for the sake of simplicity it might be stated as "The depth from which the maximum quantity of coal is raised." Now this could be determined if we had before us the depths of all the coal pits, or their workings and the output from each particular seam; but this could not be obtained without investigation into details which proprietors might not wish to have revealed, and which we should have no right to demand. There could be no objection, however, as it seems to me to the disclosure of the depth of all the pits in a coal-district and the name of the seam worked; in fact, these details are generally fully known; and if we take these details as a sufficiently close approximation, and make a correction for the cause indicated above, we may come to a tolerably close approximation as regards the average depth.

Such details regarding the great coalfield of Yorkshire, Derbyshire, and Notts have been furnished to me by my

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friend Mr. J. T. Boot, Mining Engineer, of Mansfield, and from a comparison of the depths I have obtained the following results, which may not be without interest:—

DEPTHS OF COLLIERIES IN THE COUNTIES OF YORK, DERBY, AND NOTTS.

	Yds.	Collieries.		Yds.	Collieries.
Between	0 and 50	.. *8	Between	300 and 350	.. 8
,,	50 ,, 100	.. *14	,,	350 ,, 400	.. 2
,,	100 ,, 150	.. *31	,,	400 ,, 450	.. 2
,,	150 ,, 200	.. 21	,,	450 ,, 500	.. 5
,,	200 ,, 250	.. 14	,,	500 ,, 550	.. 4
,,	250 ,, 300	.. 10	,,	650 ,, 700	.. 1

Mr. Boot states that in any estimate as to the average depth of mining the shallow pits ought not to be taken into account; some of them not being even at work. If then we disregard all the pits under 100 yards, and assume that the output of the deeper pits (say, those over 250 yards) is about double that of the shallower (under 250 yards) we shall find that the maximum output will be at a depth of about 250 yards, there being 66 collieries above that line and 32 below. I think 250 yards is, in all probability, a close approximation for this great coalfield, considering that, owing to a general low dip of the beds, and the occurrence of local flexures (forming synclinal and anticlinal curves), the seams remain at comparatively shallow depths over large areas.

As regards the Lancashire and Cheshire coalfield, including that of Burnley, I feel satisfied from my own knowledge that the case is different, and that a depth of 250 yards would by no means represent the average for coal production. Perhaps some member of the Society would endeavour to work the question out for this district on the principle I have adopted above for the Yorkshire and Derbyshire district; or upon some more reliable data. On the whole I am of opinion that a depth of 350 to 400 yards would represent more nearly that here under discussion.

* Some of these not at work.

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As regards other coalfields, those of Newcastle, Central Scotland, Staffordshire, and South Wales are the most important; and, as far as my information extends, I am led to believe that a similar depth (that of 350 yards) represents that from which the maximum quantity of coal is now being raised.

In conclusion, I would venture to urge on Her Majesty's Inspectors of Mines, and especially on Mr. Dickinson, the importance of taking up this problem with reference to each of the coalfields under their charge; as by such determinations we shall arrive at a truer knowledge of the progress of the exhaustion of our coalfields than by any other method.

The thanks of the meeting were given to Professor Hull for his valuable paper.

Mr. BURROWS: I think Her Majesty's Inspectors have the depths of each pit and the quantity of coal raised, and if the information is wanted for any special purpose, the facts are there—it is only a question of striking an average.

Mr. DICKINSON: Perhaps I might say, Mr. President, I have had this subject under my consideration, but I have not quite seen my way clearly how to frame an accurate table. In the first place, if you go back to the early accounts of the production of coal in this Kingdom they are very unreliable. Many of them were framed simply on supposition, there were no actual returns. If you go back to the commencement of the inspection of mines some tolerably accurate returns were obtained. There were also annual statistics published by the late Mr. Robert Hunt, they were tolerably reliable, but could not be said to be strictly accurate. He issued circulars to all coal owners, and those who thought fit to reply did so, but about one-third did not do so, and quantities had to be assumed. Now, since Acts of Parliament have made these returns compulsory we have reliable statistics through the Inspectors of Mines; and so

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far as these extend back the quantities are reliable, but do not give the depths at which the coal is worked. We have, as Mr. Burrows said, returns of the depths of every pit in the Kingdom, but as Mr. Hull points out that seams are worked in the same shaft at different depths. There is one difficulty. But I do not think it is the greatest difficulty; there is the difficulty arising from the inclination of the strata, which is far greater. I could cite instances in this very district of Manchester where the coal in the same pit, and in the same seam, is actually being worked where the highest part of the working is 400 yards higher vertically than the lower part. You could not expect coal owners to give you the returns of quantities got from each 50 yards of such depths. It could not be done with accuracy. We could take the depths of the pits, and assume that all the coal got from those pits was worked at that depth from the surface, which would roughly average the coal worked on the rise with that worked on the dip. The Belgian reports for 1888, give such an account for every 100 metres in depth, and they begin first with all the coal worked at less than 100 metres, and then go on giving the quantity between each successive hundred up to, I think, 1000 metres. The system of work in Belgium enables the quantity got from respective depths to be ascertained with great accuracy, as the pits are sunk only a certain number of metres each time, and then the coal between that and the former working is worked off. With regard to the introduction of the steam engine in mining, I would like to say that Mr. Matthias Dunn, in his work on the Winning and Working of Collieries, quoting from Mr. Hudson's History of Northumberland, says: "The first steam engine was erected at Byker in 1714, and that after Beighton's invention in 1718, by which the vacuum was made to work automatically instead of by hand, the erection of engines

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became general throughout the Northern District, and that at Whitehaven, so early as 1776, one was placed underground at a depth of 160 yards."

Mr. BURROWS: The engines referred to were for pumping purposes perhaps.

The PRESIDENT: I do not quite glean from the paper what would be the value of the statistics when you have got them. I think it would be possible to get statistics of that kind without much difficulty. It would be easy to make out what proportion of coal had been worked lower than a certain depth during the last 20 years, and to show how that proportion increases from year to year. But, as I said, I do not quite see the value of the statistics when you have got them. What bearing have they?

Mr. DICKINSON: At our last meeting, Mr. President, you gave us a paper on the probable duration of our coal supply, and you asked a question as to whether some assumed depths at which it was said coal could be worked, were really practicable. Professor Hull thinks it would be very desirable if we could ascertain the rate at which we are approaching to those depths, some of which you thought were impracticable.

The PRESIDENT: Well, it has a certain bearing in that direction. But it would be quite easy to get these statistics, I think.

Mr. DICKINSON: It would be quite easy to get them, so far as the depth of the pits is concerned, but where, owing to the dip, the coal varies as much as 400 vertical yards in depth, and all worked from the same shaft, you could not separate that worked in the shallower from that in the deeper parts.

The PRESIDENT: You want to make out at what rate deep mining is increasing—that is the object, as I take it, of what Mr. Hull asks. Well, you can do that by ascertaining what quantity of coal was brought from below 500 yards

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10 years ago, and how much that quantity has been increased up to the present time; you could get an average in that way and it would show the rate of increase at the lower depth.

A Member asked: How would they get the back dates?

The PRESIDENT: These have been returns made to the inspectors for 10 or 20 years back—not from individual seams, but from the whole of the workings in particular pits.

Mr. WINSTANLEY: There are persons present who can corroborate what Mr. Dickinson has stated: the workings are on a level with the pit, and in some cases, 800 or 1,000 yards down brow, where there may be an inclination of one in three.

The PRESIDENT: 400 yards below the depth of the pit.

Mr. WINSTANLEY: About 400 yards vertically below the depth of the pit.

Mr. PILKINGTON said he did not quite see the practical use of the statistics asked for by Mr. Hull. It depended on the quality of the coal at given depths whether it was gotten or not. If there was much left it would be because it was not, at existing prices, worth getting. There were mines in their district not gotten simply because they were not worth getting. Many years hence, when coal becomes more valuable, they would be worth getting. They were shallower than many now being gotten.

Mr. WATTS referred to mines which he said had been re-opened for the purpose of getting coal that had been left in previously. The lower coal seams, as they all knew, were very thin; still manufacturers in the district referred to found it to their interest now that an advance in price had taken place to open out these shallow mines. With reference to the inclination of the strata, it seemed to him not an impracticable thing if a proper survey were made, to show the quantity of coal extracted at each pit. Contour levels could be taken and an average could be made of the quantity extracted.

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Mr. WILD said it seemed to him that, owing to the tendency to select central situations for shafts, it would be almost sufficient to take the depths of the pits as an average for the coal. There were many deep dip-workings in the country, as they all knew, but they generally took to the rise, and he did not expect the dip coal to be greater than the rise.

In the course of further conversation the PRESIDENT suggested that the question might be introduced for further discussion at the Wigan meeting in January.

Mr. GRUNDY expressed the opinion that it was a question which might be entrusted to a small committee, to collect information and report upon.

Mr. DICKINSON: My own opinion is that the Inspectors of Mines are the people to do it, if it is to be done properly. They have the actual quantities sent to them; those quantities are confidential, and can only be published in such a form that the produce of any one colliery cannot be ascertained; but, if the depth of the shaft may be taken as the basis, the quantities from the respective depths might be averaged without divulging any individual return.

Mr. STIRRUP: I suppose Professor Hull's object is to ascertain the rate of exhaustion of our workable seams of coal—that is, in fact, to ascertain the probable duration of our coal supplies. That is really the same question as our President brought forward in his address. I dare say if Professor Hull had these facts before him they might be of service in the calculation.

Mr. DICKINSON: I wish Mr. Hull had been here to explain his own views. Most of you will know that he added the Geology to the Ordnance Map of Lancashire, and the subject is one in which he has taken a considerable amount of interest. I think it was at the Manchester meeting of the British Association that he gave us diagrams

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of principal coal fields, showing the depths by contour lines in the respective basins.

Mr. GRUNDY: It appears the object is to find out the rate of exhaustion at different depths.

Mr. STIRRUP: The rate of exhaustion of the *workable* seams—those that are likely to he able to be worked either at the present price or future prices, till Nature steps in and puts a stop to your operations—unless a capable engineer can discover a means of ventilating mines at very much greater depth than at present.

Mr. DICKINSON: I was at the bottom of a deep mine last month—1020 yards in vertical depth below the surface—and I did not find the temperature unpleasant. It was, I think, about 82 degrees.

Mr. BURROWS: I fancy a more important element than the temperature would come in, that is—the pressure of the atmosphere upon the tissues of the body. People work in other trades, in iron works for instance, and in cottton mills when the gas is lit, at a temperature of as high as 96. Of course they perspire, but they feel no ill effects. But under ground I have always thought that men get more tired and perspire more freely on account of the extra atmospheric pressure to which their bodies are subjected—the greater strain on their tissues.

Mr. DICKINSON: In going down these deep shafts, the only thing I feel is a little sensation in the ears and that is only for a few seconds.

Mr. BURROWS: You may not feel it, but you would not do as much labour in such a mine as in one—say 50 yards deep.

The PRESIDENT: Was the place where the temperature was 82° a part of the mine recently opened?

Mr. DICKINSON: It was in the face of long wall—1,020 yards in vertical depth.

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PEMBROKESHIRE AS A FIELD FOR THE STUDY OF GEOLOGY.

With Map of the District.

By Mr. H. W. Williams, F.G.S.

(Communicated by Mr. Mark Stirrup, F.G.S.)

The British Isles contain examples of all the rocks to be found within the limits of the European Continent, and perhaps no area within the limits of the British Isles forms so diversified a field for the student of geology as does the County of Pembroke. But because of the remoteness of this county from places where scientific societies and clubs are established, it is to many students a *terra incognita*, and but little is known of its special geological features.

This paper is undertaken with the view of bringing the district under the notice of students, and to show them by a brief sketch where unusually clear sections of the older rocks may be seen, where detail can be studied, and where a thorough knowledge of the rocks forming the lower systems may be obtained.

Along the line of coast from Porthgain (where, by the way, Manchester men are engaged in wresting treasures from the rocks) to Tenby, we have a range of strata extending from the Archæan to the top of the coal measures, with here and there patches of Pleistocene and Recent.

It will be unnecessary to point out at length what a large and interesting and important part of the Earth's crust these rocks form. The range, indeed, is so great that it will be convenient for the present to confine our attention to the older rock-formations, the Archæan, the Cambrian, and the Lower Silurian, leaving the higher rocks to be dealt with at some future time.

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PORTHGAIN
INDEX
Dumetian
Arvonian
Pebidian
Carnii Gro
Solva Gro
Menevian
Lingula
Tremadoc
Arenig Gr
Llanvirn
Llandilo
Carboniferous
Alluvium
Greenstone
Felspathic
Diabase
Intrusive
Interbedd
Faults
Tremaenhir
St. Elvis.
Ramsey Island
Aberiddy
Solva
C FAULT
SECTION FROM SOLVA TO ABEREIDDY BAY.
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The St. David's district, which is the area referred to, contain the following groups or sub-divisions, named in ascending order :—

The *Dimetian*, a granitoid rock.

The *Arvonian*, composed of halleflintas and quartz-felsites and breccias.

The *Pebidian*, composed of agglomerates, breccias, and porcellanites, felsitic tuffs, quartz-felsite breccias and sheets, diabase breccias and sheets, and purple and green schistose breccias.

These together form the local Pre-Cambrian series.

The *Carfai Group*, including the basal conglomerate of the Cambrians, green and red shales, and purple grit and sandstone.

The *Solva Group*, of purple, red, and grey grits, and flags and shales.

The *Menevian Group*, dark slates and flags.

The *Maentwrog Group*, of slates, flags, and sandstones.

The *Ffestiniog Group*, grey arenaceous and micaceous flags.

The *Dolgelly Group*, soft black slates and shales.

The *Tremadoc Group* of dark slates and flaggy sandstones.

These form the local Cambrian series.

The *Arenig Group*, slates, flags, and sandstones.

The *Llanvirn Group*, grey flags and black slates.

The *Llandilo Group*, calcareous shales, slates, flags, and sandstones.

These form the Ordovician, or Lower Silurian, according to Murchison's classification.

The student, by making St. David's or Solva his head-quarters, may see all these groups in the course of a few excursions, as both these places are within easy reach of all the exposures from which Mr. Salter, Dr. Hicks, and other eminent geologists obtained their data.

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The Archæan Rocks.

These rocks, which only in recent years have been assigned their true position in the succession, present locally some exceedingly interesting features, which might be explained here with benefit to those who have not had the opportunity of studying them either on the ground or on paper. Generally speaking, these rocks are all more or less metamorphic, many of them of volcanic origin, and some portions of them so closely resemble igneous rocks that many geologists of eminence believe them to be metamorphosed igneous rocks. The Archæan rocks shewn in the accompanying sketch map formed the subject of a prolonged discussion between the professional Fellows on the one hand and the amateur Fellows of the London Geological Society on the other hand. Dr. Geikie, the Director General of the Geological Survey, championed the professional view, whilst Dr. Henry Hicks, F.R.S., maintained the views of himself and brother amateurs. Sir Andrew Ramsay had described in the official map some of these rocks as Syenite and Felstone intrusive in and altering the Cambrian strata. Dr. Hicks was born on the ground, and having had exceptional advantages for studying it inch by inch, ultimately arrived at the conclusion that the so-called syenite was not intrusive in the Cambrian rocks, but was a peculiar granitoid rock of pre-Cambrian age, and proposed for it the new name "Dimetian," it being deficient in the basic silicates which produced the characteristic banding of the Scotch gneisses, and could not, therefore, be correlated with the "Lewisian."

Dr. Hicks also found that the so-called intrusive Felstones in many cases were volcanic breccias and lavas, and some sedimentary rocks of pre-Cambrian age, which he named "Arvonian;" and that the so-called altered Cambrian belonged also to a pre-Cambrian period, and named it "Pebidian."

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Dr. Geikie re-surveyed this area in 1882, and after carefully going over the ground he freely admitted that there were some important errors in the map, but emphatically declared that the survey map was in its essential features correct, and challenged Dr. Hicks to produce a pebble of the Dimetian from the conglomerate.

Dr. Hicks produced at a subsequent meeting of the Society specimens of the basal conglomerate of the Cambrian, containing fragments of the Dimetian, and also shewed that the Arvonian rocks were almost entirely built up of materials which could only have come from the Dimetian rocks, and thus proved that these were older formations and could not possibly be described as newer intrusions.

Dr. Geikie after this abandoned the field to his victorious opponent, and the question has not been re-opened.

The Archæan rocks are exposed in Pembrokeshire, besides the places shewn in the map, at Johnston, Goultrop, Talbenny, Rosemarket, Brawdy, Hayscastle, Roch, and Trefgarn. The best exposures of the Archæan rocks in the St. David's district are at south side of Ogof-Golchfa, shewing the Cambrian conglomerate resting unconformably on Pebidian rocks; between Castell and Ogfeydd Duon, shewing unconformity of Cambrian on Pebidian; in the east harbour, Porthllisky, shewing contact of Pebidian with Dimetian, and line of fault between; at Ogof-Llesugn, shewing contact of Cambrian with Dimetian; in quarry on north side of Porthclais, on south side of Porthclais, and on roadside between Porthclais and Rhoscribed, shewing faulted contact of Cambrian with Dimetian; and in cliff S.E. of Nun's Chapel, showing conglomerate resting on edges of Pebidian beds.

The Cambrian Rocks.

The basal conglomerate of the Cambrians forms a distinct boundary line between the Cambrians and the

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pre-Cambrians, and being mainly the result of the erosion of the Archæan rocks it contains a number of recognisable fragments of these earlier rocks. This basal bed is succeeded by the green flaggy sandstones, schists, red shales, and the purple sandstone which everywhere characterise the lower beds of the Cambrians. The red shales of Carfai have yielded the oldest remains of invertebrate animals, the *Leperditia Cambrensis*, *Lingulella Primæva*, and *Discina Caerfaiensis*. These are the lowest evidences of the earliest life yet obtained. A mineral found in lower rocks in Canada was at one time thought to be an earlier fossil, but the theory has been abandoned, and it is now admitted to be a mineral development. The best exposed section of these rocks is to be found in the neighbourhood of Carfai, and in the Caerbwdy Valley, near St. David's.

Next to these in the succession come the Solva Group (Harlech Grits), which gradually pass into the Menevian group. An interesting section from the Carfai Sandstone up to the Menevian beds may be traced in the Solva Valley.

The Menevian beds are richly fossiliferous, and the fauna belonging to this group, which is only about 750 feet thick, consists of 52 species of 23 genera, and this group has become famous among Palæontologists on account of its peculiar fauna. The best exposures are at Solva Harbour, Dwrhyd, and at Porthyrhaw.

Immediately succeeding the Menevian beds at Porthyrhaw and Solva are found in their natural order the basal beds of the Lingula flags, and the Lingula series, the Maentwrog, Festiniog, and Dolgelly groups may be traced across Solva Harbour into the St. Elvis Cliffs, south-eastwardly, where replicated Menevians are met with, which are again succeeded by a southerly fold of the Cambrian sandstones exposed near Newgale. Here the carboniferous rocks are thrust in amongst the older rocks by faults.

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The Tremadoc slates are exposed at Whitesand Bay, Ramsey Island, and at Tremaenhire.

We have the authority of Sir Roderick Murchison for stating that in the Whitesand Bay tract the "connection of the lowest formation of the Silurian system on the Lingula flags and Tremadoc slates, with the Lower Llandilo rocks, is better seen, perhaps, than in any other part of Wales and England."

Ordovician and Silurian Rocks.

In due order succeeding the Cambrians we have the rocks of the Lower Silurian (or Ordovician) series well exposed on the northern coast line, and a splendid section may be seen during the course of a walk along the cliffs from Whitesand Bay to Porthgain. First in this series comes the Arenig group, which in turn is succeeded by the Llanvrin, Llandilo, Bala, and Llandovery groups.

The Bala and Llandovery groups are not to be found within the area referred to, but these are the beds upon which the town of Haverfordwest is for the most part built.

The Dynamical, Structural, and Physiographical Features.

The pre-Cambrian rocks bear evidence that there was during Archæan time a period of excessive volcanic activity, proving that there are good grounds for the assumption "that volcanic action was probably more general and more intense in early geological time" than it is at the present stage of the world's history. In these rocks we have the remains of the oldest volcanoes which have yet been discovered. The evidence goes to show that the period of greatest activity was when the agglomerates of the Pebidian series were laid down. The Pebidian group in this area attains a thickness of about 8,000 feet, and in these rocks tufa and volcanic products predominate, and the evidence still further shows that the accumulations were at first

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sub-aërial, gradually passing into submarine, accumulations, tending to prove that after the lower courses had been deposited the whole area became submerged whilst the volcanic activity remained unimpaired. Then there was a re-elevation of the depressed land and consolidation of the rocks before the Cambrians began to be deposited. Evidence of volcanic activity also is recorded in the basal beds of the Lingula flags, but the activity was not accompanied by any important physical changes. The Lower Cambrian series in this area attain a thickness of nearly 5,000 feet, and no inconsiderable time must therefore have elapsed between the Pebidian volcanic period and the volcanic activity at the close of the Menevian period. Dr. Geikie mentions the occurrence of tufa in the conglomerate and in the Solva group exposed at Middle Mill, in Solva Valley, and in the same group exposed in Cwm Mawr, N.W. of Newgale, and it may be that all these are the emanations of the still slumbering Pebidian volcano, spread over the long period from Pebidian times to the days when the foundations of the Lingula flags were deposited, and not the result of entirely new outbursts. The volcanic activity recorded in the Lingula flags is seen in thin lines of interbedded ash exposed in Solva Harbour and at Porthyrhaw. Another lengthy period elapsed before the next evidence of volcanic activity was recorded—in the Arenig, Llanvirn, and Llandilo rocks—to be seen in various exposures of these rocks on the northern coast-line, more particularly at Abereiddy Bay, where there is one thick bed of felspathic ash with several smaller bands of volcanic grit alternating with the fine argillaceous beds.

Locally, however, the interbedded volcanic products give way in point of interest to the intrusive and eruptive rocks, and as factors in the present physical features of the landscape. In the Dimetian and Arvonian rocks we have

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intrusive felsite and porphyritic quartz-felsite and diabase sheets and dykes, and in all the succeeding rocks bosses, sheets, and dykes are frequent and common. Through the Cambrians and Silurians, intrusive sheets seem to have been driven at very frequent intervals, and, the beds having been subsequently folded and broken at their anticlines, the sheets appear on the surface as independent strings or vertical intrusions. Rocks of all ages are broken up, and huge masses have been moved about from place to place in such a manner as to prove that the disturbances were frequent, general, and excessive. At Whitesand Bay there is a thrust, according to measurements taken by Dr. Hicks and Professor Hughes, of fifteen thousand feet, and a fault, beginning at Porthyrhaw, extends nearly across the St. David's promontory, a movement resulting in the complete fracture of the huge mass of solid Arvonian and Cambrian rocks, and another fault, extending many miles, runs directly across the latter in an east and west direction. In Ramsey Island, at Porthclais, and in the neighbourhood of Porthyrhaw, there are numerous faults ; and, in the Porthyrhaw Valley, the tufaceous basal beds of the Lingula flags form an admirable key to the series of dislocations and thrusts to be seen there.

The coast line included in this sketch provides the student with an endless variety of simple and complex examples of contorted, inverted, and faulted strata, false and true bedding, jointage, cleavage, ripple marks, suncracks, and mineral veins and deposits—in short, every feature of geology requisite to complete the student's first lessons. In addition, here may be seen proofs of alternate upheaval and depression, of depositions and accumulations, of erosion and denudation, all as clearly recorded as in a text book. The Cambrian conglomerate lying on the older rocks, proves itself to be the result of the erosion and denudation of the rocks it

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rests upon, and indicates the gradual advance of the waves of the Cambrian sea over a sinking shore. The pebbles and coarser gravel were too heavy to be carried far, and after having been rolled about and rounded, sank into their resting places as the fringe of the disturbed water advanced. These pebbles formed the beach-line of Archæan times. Upon this conglomerate lies the Archæan detritus next in weight, and upon this the still lighter material, which, being more easily removed, was carried out to sea and deposited in the quiet depths. The Carfai section furnishes an excellent example of erosion and redeposition.

The non-existence of Caradoc rocks to the east of the Longmynd tends to prove that the whole of the British area, with the exception of a small ridge in the centre of the present England, was submerged in order to receive the Cambrian and Silurian beds. The depression probably began at the close of Archæan time, and was continued with fluctuations, during which partial re-elevations at different places occurred, until re-elevation to the present level, with the attendant denudation took place. Dr. Hicks says: "The sequence of the rocks in the promontory of St. David's is a perfectly continuous one from the base of the Longmynd (or Solva) group to the Llandilo group, and that in this section there are no lines of division stronger than what would naturally occur in a great series deposited over a sea-bottom becoming gradually depressed, and subject to the ordinary physical influences which must have prevailed during such a time." This means that this promontory gradually sank lower and lower until it received at least the Llandilo rocks. It is probable, if the evidence of these rocks is accepted, that the land became very deeply submerged, as most of these rocks being composed of very fine sediment, were very likely deposited in quiet, deep water. The bands of limestone in these beds also tend to prove this view.

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It is thought that numerous volcanic islands made their appearance about this time, somewhere between Wales and Ireland, the lava streams from which are now found imbedded with the Llanvirn and Llandilo rocks. It is probably to these volcanoes, the last British volcanoes of which we have any evidence, we owe the re-elevation of this tract of land.

As the land rose above the water the process of denudation went on, until the rocks were stripped to their present heights.

The promontory of St. David's, as seen from the top of one of the rugged masses of intrusive rock, which form such prominent features of the landscape on the northern coast, presents the appearance of a table land with valleys excavated to the sea level.' All the rocks bear unmistakable testimony that great and continuous denudation must have taken place to reduce the rocks to their present level, but how much of the denudation was effected by submarine, sub-aërial, or by glacial causes, remains to be shown. There is, however, no doubt but that this area suffered largely during the great ice period. Where glacial drift occurs, and the underlying rocks are exposed as in the valley of the Cleddau, at Whitesand Bay, and at other places, glacial striæ may be seen. Patches of ice-borne drift will be met with at frequent intervals, not only in the valley, but also on the higher ground, and striated boulders are common objects on the supposed table land.

Evidence of the last great subsidence which separated the British Isles from the Continent will be found at various points along the coast in the form of submerged forests. After a heavy storm the beaches at Newgale, Whitesand Bay, and Abermawr are laid bare, and the stumps and roots of trees *in situ*, fallen trees with their roots, branches, leaves, and fruit lie as they fell, with hazel-nuts, ungerminated, thus tending to prove that the local submergence

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was as complete as it was sudden. Some years ago Dr. Hicks unearthed the jaw-bone of a brown bear and the antlers of deer from the black soil below high-water level at Whitesand Bay.

Recent.

Palæolithic and Neolithic tools and weapons are sometimes found in the vicinity of springs near the Cromlechs and pre-historic camps which abound in this district.

Palæontological.

Although the researches of Dr. Hicks and others on this ground have done so much to throw light on the life of earlier Palæozoic time, there no doubt remains a great deal to be discovered in this area. The well-exposed sections afforded by the high cliffs lay before the student a rich and profitable field for the study of Palæontological Geology. As it would take several papers to give even a brief description of the Palæontological features, more than general reference here is neither advisable nor possible.

Industrial Products.

A country possessing so great a diversity of rocks would naturally be expected to yield a variety of industrial or economic products, and much mineral wealth.

Owing to the lack of mining enterprise amongst local men, comparatively little has been done to develope the mineral wealth of the county, and, with the exception of the anthracite coal beds, it may be said that the mineral resources remain untouched.

The coal measures yield culm and anthracite coal exceptionally rich in carbon. The anthracite coal of South Wales is said to have 96 per cent. of carbon. The coal won finds a ready market at good prices.

Auriferous veins have been proved to exist in nearly all the series within the gold limit, but nothing has ever been

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done in the way of gold mining in Pembrokeshire. All the geological conditions for gold are present, and upon diligent search, gold in paying quantities may possibly be found.

Various copper and lead lodes have been explored, and although the latter mineral has been found to be unusally rich in silver, nothing beyond superficial working has ever been attempted, except at Llanfirnach, where a lead mine is being worked most successfully.

Manganese oxide deposits of considerable extent are to be found in North Pembrokeshire, in the Llandilo rocks, and it is understood that the attention of commercial men is now being directed to one valuable property in this district.

Rich ironstone is found in the coal-measures, particularly at Broad and Little Haven.

The Lower Cambrian beds yield a sandstone of a beautiful purple colour, suitable for building purposes. This is the stone so largely used in the building and restoration of St. David's Cathedral. Very large blocks of this stone can be obtained and would well repay quarrying. The carboniferous limestone beds also furnish good building stone, and a fine grey building stone may be got from the carboniferous sandstone exposed at Nolton.

The local greenstone sheets and bosses also yield good building stone, and large blocks may be obtained. When rough dressed and used as a facing stone in buildings, its soft green tone has a very pleasing effect. This stone also dresses very readily into paving setts of excellent quality, as it is only just sufficiently hard to wear well without acquiring the dangerous slippery polish so objectionable in the pure granite setts. This stone may be obtained in abundance, and as works for dressing and preparing it for the markets have been opened at Porthgain, it is likely that a large local industry will be developed in the course of time.

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Roofing slates of good quality are obtainable from the local Arenig, Llanvrin, and Llandilo rocks, wherever these rocks are exposed in the county; but, except at Porthgain, where facilities for shipment exist, the lack of means of transit preclude the hope that the wealth of these rocks is ever likely to be fully realised. Several extensive beds of roofing slate are to be found within easy distance of Fishguard, and the shipping facilities of the harbour at this place may yet be used for the exportation of slate. The slabs obtained from these rocks find a ready market.

The slaty rocks of the Lower Silurian groups, when pulverised and properly treated, may be made into bricks of surpassing strength.

The metal aluminium is present in large quantities in the clays of North Pembrokeshire, and also in the felspar rocks commonly found in the locality. When it becomes possible to extract aluminium by a cheap and easy method, so as to bring it within reach of the Industrial Arts, North Pembrokeshire may become an important mining district.

A vote of thanks was passed to Mr. Williams for his interesting communication.

This concluded the business of the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XX. SESSION 1889-90.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, the 10th January, 1890, in the Mining School, Wigan. Mr. W. S. BARRETT, Vice-President (in the unavoidable absence of the President), was called to the Chair.

MEETING AT OWENS COLLEGE.

The Chairman said he had been asked to mention that arrangements were being made for an Evening Meeting at Owens College, at the end of this month. That, he was sure, would be satisfactory to the members, because the previous meetings there had been of an interesting and instructive character. Due notice would be given of the date of the meeting.

NEW MEMBERS.

The following gentlemen were elected Ordinary Members the Society : —

G. E. J. MCMURTRIE, Mining Engineer, Poynton, near Stockport.

THOMAS MORRIS, Mining Engineer, Rosebridge Collieries, Wigan.

J. RICHARD HAINES, F.G.S., Adderley Green Collieries, Stoke-on-Trent.

JOHN GREEN, Mining Engineer, Bamfurlong, Wigan.

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DESCRIPTION OF A PATENT SCREEN.

By Mr. G. C. Greenwell, Jun., M.I.C.E., F.G.S.

Not by any means the least important part of the duties of the manager of a colliery is to see that the coal is economically and efficiently screened, and that as much of the dirt and dross is picked out before the coal is placed in the wagons as possible.

The system of screening, which has generally been adopted till comparatively recently, and is even now very largely in use throughout the country, is the simple arrangement of fixed sloping bars placed parallel to each other at various distances apart, depending upon the size of coal which it is wished to pass through between the bars.

The objection to this system, which otherwise answers very satisfactorily, is that if the inclination of the bars is steep so as to allow the coal to pass down to the wagon by force of gravity, there is no time or opportunity for picking out the dirt and dross, and a large amount of this passes into the wagon mixed with the coal, and if the inclination of the bars is not so steep, the dirt and dross can be picked out, but the labour in raking down the coal to the wagon is considerable, and consequently expensive. During recent years many mechanical contrivances have been adopted at various collieries to economize labour, such as Shaking Screens and Revolving Screens, worked by engine power, which after separating the large from the small coal deliver the large coal direct into the wagons or on to travelling belts variously constructed, which carry the coal past the pickers,—men, boys, and sometimes women, who take out the dirt and dross, and where necessary separate the large coal according to its quality. What passes the pickers is then either delivered direct into the wagons or on to other Shaking or Revolving Screens for further separation.

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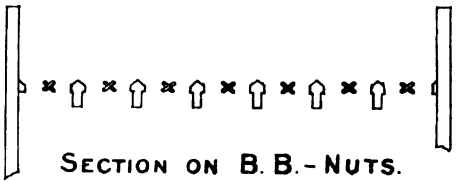
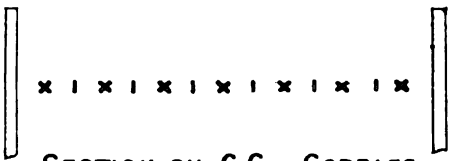
SECTION ON A.A. – SLACK.



SECTION ON B.B. – NUTS.



SECTION ON C.C. – COBBLES.

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The slack which passes through the first Shaking or Revolving Screen is also, when not delivered direct into wagons, often conveyed, by means of belts, elevators or other arrangements, to other screens of a similar description, and separated into as many different sizes of coal as required.

These screens do their work very thoroughly, and the belts, which are sometimes of considerable length, enable the pickers to clean and sort the coal in a very perfect manner, but the great objection to the arrangement is the heavy first cost, the high working cost, and the large amount of room required.

The writer does not propose to describe these screens more fully, as he has no doubt that most colliery managers are familiar with them. He will now, therefore, proceed at once to describe an arrangement for screening and picking, which has been in use at Lord Vernon's Poynton Collieries for about two years, and which has answered remarkably well. It will be seen by the Plan and a small Model, which are before you, that the arrangement consists of a series of paralled short linked endless chains, driven by engine power, and working between fixed bars of a particular section and of various widths. The coal is tipped on to the screen, and is carried forward by the chains, which travel at a slow speed, and as it passes forward, the dirt and dross is picked out by men, boys, or women, stationed at intervals on each side, and the various sizes of small coal drop through between the chains and bars into wagons placed below. The smallest size passing through in the first length, and the larger sizes in the succeeding lengths, until at the end of the screen the large coal is delivered, free from small and dirt, into the wagons placed ready to receive it. It will at once be seen that the screen may be erected of any length and with any number of sections, and that by putting a sufficient number of small guiding pullies to

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keep the chains steady, the coal may be very accurately sorted into as many different sizes as required. The plan shows the arrangement adopted at Poynton, and is suitable for the particular requirements of the colliery, but this arrangement could be varied very considerably.

The cost of erection is comparatively small, and the screen can be fitted up and set to work without much interference with existing arrangements. A large amount of coal can be passed over one screen and can be efficiently dealt with at a very low working cost. The following particulars with regard to the two screens which are now at work at Poynton may be of interest:—

Speed of chains	73 feet per minute.
Quantity of coal dealt with	100 tons per hour.
Equals for each screen	50 tons per hour.
Working cost	¼d. per ton.
First cost of each screen	Under £100.

The writer will be very pleased to give any further information to any member of the Society, and to show the screen at work to those who would like to see it.

The CHAIRMAN said he personally regretted there was not a larger attendance. The great ambition of colliery proprietors was to give the public their coal as clean as possible. They had always tried to do that, and therefore anyone who helped them to do it was entitled to their gratitude. He was sure the subject brought under their notice was very important to mining engineers and others interested in the question which was of the greatest value to them. Although Mr. Greenwell's paper was short it was concise and full of information, and he could only on behalf of the Society offer him their thanks, and invite any gentleman to ask what further questions they desired. He begged to propose a vote of thanks to Mr. Greenwell.

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Mr. CALDWELL: I should like to know whether it is not possible for lumps of coal to get between the bars and chains of the machine, and thereby stop its working?

Mr. GREENWELL: I think not. The chains, which are short linked, in passing over the pulleys give a shaking movement, and they act in a certain way as a riddle. In our experience, which has extended about two years, there has never anything of the kind happened.

Mr. CALDWELL: Then the coal and the slack go down their proper apertures?

Mr. GREENWELL: Yes, except to a slight extent where the coal is of a flaky description.

Mr. CALDWELL: That would apply to any screen?

Mr. GREENWELL: Yes, except in shaking and revolving screens with a mesh.

Mr. HOLLINGWORTH: What sort of a chain is used?

Mr. GREENWELL: An ordinary chain with short links. It is practically round and like a rope.

Mr. HEDLEY: What is the incline used?

Mr. GREENWELL: We first tried a steepish incline but gradually lessened it, and now it is quite flat.

Mr. HEDLEY: You say it costs a farthing per ton?

Mr. GREENWELL: Yes, as an average working cost.

Mr. HEDLEY: Your coal is comparatively clean?

Mr. GREENWELL: I wish it were.

Mr. HEDLEY: Compared with other places?

Mr. GREENWELL: Much the same.

Mr. HEDLEY, in seconding the motion, said they were deeply indebted to Mr. Greenwell for coming such a long distance and laying before them a subject which was of very great interest and importance to them. The idea was quite a new one to him, and to many members present. He could only regret there were so few present from the district, for he felt sure when the paper had been printed it would be

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read with great interest by all who were connected with collieries, and he had no doubt some of them would be glad to avail themselves of Mr. Greenwell's offer to show them the screen in operation.

The CHAIRMAN explained that there was an important arbitration being held at Manchester, and it probably prevented a larger attendance.

The motion having been passed, Mr. Greenwell briefly replied, and said he would be glad to give the members any further information.

The CHAIRMAN said, that concluded the business. It had been a very short, but very interesting meeting, and he trusted they would have as profitable a one when they met there again.

Mr. C. COCKSON, in proposing a vote of thanks to the Chairman, said they knew what a busy man Mr. Barrett was, and his example in attending those meetings ought to induce other colliery proprietors and managers from that district to attend. He was sure that those present were much obliged to Mr. Barrett for his attendance and the remarks he had made.

Mr. TONGE, in seconding, said he was afraid that members had absented themselves because they thought nothing new could be brought out with regard to screening, but when they read Mr. Greenwell's paper they would admit it was something new. They were deeply indebted to Mr. Greenwell for his paper, and to Mr. Barrett for presiding.

The Chairman, in acknowledging the compliment, said that as a colliery owner he was glad to be there. He thought any time spent on a question of that sort was very well bestowed.

The meeting then terminated.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XX. SESSION 1889–90.

EVENING MEETING AT THE OWENS COLLEGE.

A SPECIAL MEETING of the Members and their Friends was held in the Geological Museum, Beyer Buildings, Owens College, on the evening of Friday, the 31st January, 1890.

Since the opening of the New Museum Buildings a meeting at the College is now reckoned upon as an annually recurrent event, a view which the Council of the Society desires to foster, as it gives the members an opportunity of meeting in a more social and less formal way than is possible at the Ordinary Meetings at the rooms in George Street.

Moreover, it affords an occasion to the members of renewing their acquaintance with the geological collections, and of fostering and sustaining their interest in their development.

Prior to the commencement of the proceedings announced in the circular, the members met in the Refectory of the College, where tea and coffee were served.

At 7 o'clock the members assembled in the Zoological Lecture Theatre, when (in the absence of the President) Professor W. BOYD DAWKINS, M.A., F.R.S. (Vice-President), was called to the Chair, who at once called upon Mr. MARK STIRRUP, F.G.S., to deliver his promised address.

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HYDROLOGY OF THE CAUSSES OF LANGUEDOC; THE GORGES OF THE TARN, ITS CAVERNS AND SUBTERRANEAN STREAMS.

(Being a chapter on Denudation and the Régime of Underground Waters.)

With Lantern Illustrations.

Mr. STIRRUP, before proceeding with his address, pointed out on a large map of France (kindly lent by the Manchester Geographical Society) the position of the district he was about to describe, and indicated its relation to the surrounding mountains of the Cévennes, some of whose highest ridges form the European divide or watershed, which separates the rivers which have their outlet in the Mediterranean from those flowing westwards to the Atlantic.

Mr. STIRRUP continuing, said, the district to which he wished to draw attention was one of special interest to the geologist, as in it were displayed some of the most curious and singular effects of the denuding and erosive power of running water that were to be met with in Europe. Situated in a portion of Southern France, in the midst of its poorest departments, as regards agriculture or commerce, this district has attracted, until recently, but little notice, and has remained practically unknown, even to the French themselves.

This neglect is probably due to many causes, some of which are its inaccessibility, owing to its comparative isolation in the heart of the Cévennes mountains, its want of roads and railway communication (a drawback now remedied), and its position away from the great stream of traffic which passes from the north to the south of France *viâ* Paris and Marseilles.

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Public attention has been recently drawn to this region by the publication of articles in several French geographical and scientific journals, in which have been described most vividly by the explorers, the attractive features and great natural curiosities which are there to be met with.

For the main facts and descriptions of the district, the lecturer acknowledged his indebtedness to the writings and statements of L. de Malafosse, of Toulouse, and E. A. Martel, of the French Alpine Club, to the latter of whom he was particularly beholden for much valuable information furnished, and also for his assistance and judgment in selecting the lantern views, some of which embodied M. Martel's own explorations, so recently as the summer of last year, and which have not hitherto been put before an English audience, and only before a French public by the explorers themselves.

The word "Causses" (evidently derived from the Latin word *calx*, limestone) is a local name, designating certain large calcareous plateaux, high table-lands, ranging from 2,600 feet to nearly 4,000 feet above the sea level, and which extend into the department of the Lot, Lozère, Aveyron, Gard, and the Hérault.

Situated between Mende, Rodez, and Montpellier, mainly in the department of "La Lozère," the Causses are bounded on the north by the basin of the river Lot, and on the east by the granite and schists of Mont Aigoual and Mont Lozère, which rise respectively to a height of 5,140 feet and 5,580 feet.

The special features of the Causses consist of deep gorges or cañons; plateaux seamed with innumerable fissures and traversed by numerous vertical, deep *avens* or swallow-holes; and rocks of marvellous shapes, the work of erosion; while the interior recesses of the Causses have been carved

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into caverns and tunnels by subterranean streams of unknown origin.

The intensity of the action of running water and of denuding agencies upon these plateaux is due for the most part to the constitution and mineral composition of the rocks which go to build up their mass.

Without entering into geological details, it may be said that the rocks of the Causses, belong essentially to the JURASSIC formation, and consist principally of Limestones, Dolomites and Marls which rest upon the LIAS.

The Dolomite is one of the most characteristic rocks of the region, and owing to its composition of calcium and magnesium, it lends itself readily to disintegration and erosion, as will be seen in the vertical escarpments and curiously eroded rocks pictured in the lantern views.

The Causses, says the Geographer Reclus, are unique in France, by their configuration, their aspect and their climate.

Of the two former characteristics, Mr. Stirrup said, some idea will be gathered from the photographic views thrown on the screen, and as to the climate, M. Reclus goes on to say, that on the *surface* of the Causses it is extreme, rigorous and severe in the winter; often impassable from the depth of snow, subject to violent storms, while in the summer it is baked with a fervent heat.

In the valleys, however, several hundred feet below, a warm and Mediterranean climate prevails, permitting the growth of almond trees, vines, and the olive. These high table-lands have been divested of their wood and are now in fact deserts, naked, dry, without water or wood, except on the edges and flanks of the Causses, among the inaccessible rocks, where remnants of their ancient forests of beech and oak still maintain a foothold.

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One of the most wonderful and picturesque attractions of this region is the river gorges, narrow ravines or cañons which separate the several Causses from one another. The walls of these gorges are for the most part vertical, rising from about 650 feet to, in some cases, nearly 2,000 feet above the stream, which flows between.

These cliffs have not been rent asunder by any great earth movement as might at first be supposed, but the severance is due to erosion by running waters.

The three principal streams which divide the Causses are the Tarn, the Jonte, and the Dourbie.

The gorge of the Tarn is the most beautiful and perhaps the most characteristic, as for a distance of about fifty miles from Florac to Millau, the river runs in a narrow, deep and sinuous crack, between perpendicular walls, which, in places rise to 1,300 and 1,600 feet, and even 1,900 feet above the river itself. It is only near St. Enimie that the Tarn first becomes navigable to the small boats which descend the stream; no oars are used to propel the boat, which glides down with the current, only the gaff or boat hook is needed to direct its course.

The river varies in depth according to places and the seasons, sometimes widening out into lake-like expanses, then narrowing again until the river fills up the whole width of the gorge.

Between St. Enimie and Rozier several rapids are traversed among the great rocks, which in places bar the passage of the stream, and where the passengers are obliged to disembark and proceed to the next navigable part.

One thing the pictures will fail to show, that is the wonderful colouring of the white dolomite cliffs when lighted up by the rays of the setting sun; spotted and dashed as they are with shades of the brightest of red, yellow, and orange,

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due to the salts of iron, with which the dolomite is impregnated.

The destructive and erosive power of running water is not only shown in the deep river gorges of this region, but also on the surface of the Causses, where the Upper Dolomite, which crowns the plateaux, has been cut and carved into the most fantastic shapes, simulating animal and architectural forms, which words fail to describe.

Among these gigantic monoliths sculptured by nature's hand, may be descried the forms of dolmens and menhirs, statues, obelisks, pyramids, arched gateways,—natural monuments, some of which stand on the verge of cliffs from 400 to upwards of 1,000 feet in height, whilst others are hidden within an outer rampart of rock, bastioned and crenellated like some feudal fortress.

Of this latter class is that great marvel of the country, a veritable city of rocks, called Montpellier-le-Vieux, or by the peasantry the Devil's City, which from its strange and unaccountable appearance has always been an object of superstitious dread to the inhabitants of the valleys below.

They dared not enter into its rocky labyrinths, and refrained even from speaking of its existence to the rare travellers who visited the locality.

This assemblage of eroded rocks, all cut out of the solid dolomite, presents the appearance of Titanic ruins, which have been compared to Karnac, Palmyra, and other celebrated Eastern ruins. It is situated upon the edge of the Causse Noir, about seven miles east of Millau, at a height above the valley of the Dourbie of about 1,300 feet.

There are several displays of a like character on other parts of the Causse Noir, at Mourèze, on the Causse Larzac, and in other districts of the Cévennes where similar rocks form the surface of the tableland.

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The underground phenomena of this curious region is no less extraordinary than its surface features, as will be seen by the views of several of the more remarkable of the avens, caverns, and subterranean streams which have been explored by M. Martel and his friends.

Avens may be described as great natural shafts or swallow-holes, common to limestone countries, such as are met with on a more diminutive scale at Ingleborough and in Derbyshire.

The avens of the Causses manifest themselves on the surface in orifices of considerable size, generally in some hollow or depression of the ground, where, in time of storms, the water finds its way, and is precipitated down these deep pits with a great noise. These swallow-holes have been considered by many to open out below the surface into large caverns, or to have direct communication with subterranean reservoirs or streams, but these surmises have not been practically tested until recently.

These exterior openings were considered to be caused by the falling-in of the roofs of underground caverns, while the vertical pit was the communication between the supposed reservoir and the surface.

Popular superstition had ascribed to many of these avens depths of 500 métres (1,640 feet), and some were pronounced unfathomable.

In the years 1888 and 1889 Monsieur Martel and his companions determined to explore some of these abysses; fourteen of them were examined, and only one, that of Rabanel, was found to be more than 200 métres (650 feet) in depth, the others varied from 180 feet to 435 feet.

As to their mode of formation, M. Martel says they cannot all be ascribed to one cause.

One only, that of Padirac, seems to owe its origin to a falling-in of the roof, and that is distinguished by a wider

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orifice (115 feet) and its moderate depth of 196 feet. All the others are too deep and too narrow to be due to the same cause. Four only end in actual caverns, and those are only of medium size. Eight are terminated by a pit, or by fissures where the head of a man could not pass; these twelve are simply natural fractures of the rocks, widened by the action of surface waters upon them.

M. Martel's sections, published in the reports of his explorations, show how erosion has proceeded. The combined mechanical and chemical action of rain water in percolating through these rocks, has enlarged the vertical fissures of the limestone or dolomite, then, having arrived at the bottom of one of these cracks, it has made a horizontal gallery where a line of weakness or intersection of joints has occurred, until meeting with another vertical fissure, when the downward prolongation of the aven has been continued, and so the work of erosion has progressed until stopped by an impermeable band of marl.

The scientific and complete manner in which these investigations were carried on, is shown by the means used. Often seven or eight assistants were employed, 500 mètres of strong ropes, rope ladders, windlasses, cranes and pulleys, telephones, electric lights, magnesium wire, tents, &c., &c. When on the way to explore one of these "avens," the convoy often attracted the attention of the country people, who often took it to be that of a strolling circus company.

The absolute necessity of the telephone, whilst engaged in these explorations, was proved on several occasions, which might have ended disastrously to the explorers, if they had not been able to keep up communication with one another by its aid, as in these pits the sound of whistles, horns or the human voice ceases to be heard at a depth of 90 to 100 feet, owing to the resonance.

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One of these "avens," that of the Egue, on the Causse Noir (of which a section was exhibited), demonstrated the general character, and the probable mode of formation of many of them.

Those who have seen the so-called "Glacier Garden" at Lucerne, will remember the "Giant's Kettles," "Pot Holes," or great bowl-shaped striated hollows in the rock, the result of the action of pebbles or boulders, gyrating under the impulse of a glacier torrent falling on the rock from a higher platform.

Similar striations or scorings may be seen on the vertical walls of the "Aven de l'Egue," and so regular are they, as to resemble the exterior mould of a gigantic screw, some 6 to 18 feet in diameter.

The spiral lines cut into the face of this long cylinder have been the work of some ancient torrent, which in its descent from a higher level has carried in with it stones and pebbles, which whirled round and round, during untold time, have gone on gradually sculpturing and deepening the shaft, until it has attained its present depth, which far exceeds that of any "Giant's Kettle" at present known.

Thus, apparently, the same mechanical action of torrential water, whether of glacier streams or not, which hollowed out the shallow "Giant's Kettles" of Lucerne produced the deep "Avens" of the Causses. The difference in the amount of erosion is only one of degree, and this is doubtless largely due to the different mineral composition of the respective rocks.

The Caverns of the Causses are no less interesting than the Avens.

While the mode of formation of these underground chambers was explained, their weird and wonderful aspect was well illustrated by the views of the Grotto of Dargilan.

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This cavern was discovered only by an accident in 1880, and it has since been explored during the summers of 1884 and 1885, after great labour and a few accidents, by M. Martel and his friends.

It is a cavern of great extent and several branches, entrance to which is gained by an opening under the edge of the Causse Noir, near the surface of the dolomitic escarpment. The first chamber and the largest is of elliptical form, 390 feet long, 160 to 200 feet broad, and 115 feet high. Its sides and roof are clothed with stalactitic crystallizations, which resemble a fairy palace of indescribable appearance.

Twenty great chambers were discovered, united by long and narrow passages or corridors, and all more or less adorned by magnificent and curiously-shaped masses of stalactitic and stalagmitic formation, of which the photographic views can but give an idea.

The lecturer explained these *dry* caverns as the work of a past geological age, while, on the other hand, the present streams are scooping out and tunneling the solid rock into chambers and passages at a *lower* level, the result of which action may at some future age be accessible to man, when the present caverns are caverns no longer, but fantastic groups of eroded rocks, like those of Montpellier-le-Vieux.

To explain the régime of the under-ground waters of the Causses, the course of the Bramabiau was traced, from its disappearance in a cavern on the surface of the plateau as an open-air stream known as "le Bonheur," to its reappearance in the valley, where it issues from a cavern in the face of the cliff at a level of 295 feet lower.

Two ancient sub-aërial beds of this stream have left well-marked traces on the surface of the plateau (which seems to have been the site of an ancient lake), proving that the waters, before having worn their present underground

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channel, were precipitated over the edge of the cliffs into the valley by a cascade of 260 feet in height.

The whole course of the underground stream has been traced by M. Martel. The exploring party, though not able to follow the course of the stream all the way, owing to its being sometimes lost in impenetrable fissures, was enabled, by taking advantage of old watercourses, now dry galleries, to pick up the stream at lower levels, thus eight cascades of varying height were encountered, as well as several small lakes and numerous hidden springs which were feeders to the stream. The exit of the stream into the valley in a recess of two great walls of rock of nearly 400 feet in height arrests attention. The great cleft has been undoubtedly produced by prolonged erosion and the falling in of underground caverns, a work which is still going on, as exemplified by an examination of the interior course of the river.

The great height, 160 to 290 feet, of the narrow subterranean galleries, through which the stream makes its way, is remarkable whilst the arched character of the roof also claims attention.

What does this demonstrate, but that you have in the underground course of the Bramabiau, an exemplification of a veritable gorge in the process of formation, that in the course of time, those vaulted roofs which at present support the plateau of Camprieu, will have succumbed under the slow but continuous effort of erosion, and that an open gorge will be the result, through which the stream will flow, like that of many an Alpine torrent, whose narrow gorges are simply the enlarged fissures of the rock, through which the torrent has cut its way.

After the exhibition of a series of beautiful and entirely new photographic views which followed the address,

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The CHAIRMAN said: I have listened with very great pleasure to the very interesting lecture which Mr. Stirrup has been good enough to give us this evening. As it is rather late, I will not call upon any gentleman to move a formal vote, but ask you to allow me to give expression to your feeling—that we are much indebted to Mr. Stirrup for this very interesting communication. I think some of the members must have visited regions in Derbyshire and Yorkshire strikingly like those described by Mr. Stirrup to-night; where these same phenomena may be seen, although not on such a very large scale. There are one or two points which interested me very much in the paper. Of course, in this country, we have not very large accumulations of Dolomite, we do not get these fantastic appearances—not, at least, of such extent,—but in the mountain limestone we do get phenomena of precisely the same sort; and although our subterranean streams are not to be compared with those of France, yet we have some subterranean streams which can be explored. Those round Ingleborough are sufficiently large to give one a certain amount of excitement in the work of exploration. It was my good fortune many years ago to spend a considerable time in exploring some of those places, and I listened with the greatest possible pleasure to the adventurous exploits of the French geologists in these very dangerous caverns. At the bottom of one pot-hole under Ingleborough, we had to work down stream; Mr. Birkbeck, of Settle, and some others of us were let down a vertical hole, about 200 ft. deep, with a cascade falling on our heads the greater part of the way, and at the bottom a series of waterfalls. We had a ladder with us, and men, and we experienced considerable difficulty in so fixing the ladder as to avoid the deep pool which is, as a rule, always at the bottom of the waterfalls. All round Ingleborough there are large numbers of caverns, in which any of you can have the same sort of amusement

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if you really care to take the trouble. There is one hole in particular, called Heln pot, some eight or nine miles from Settle; there are several caverns opening into Heln pot, which it is possible to penetrate without much danger, and where you can observe all these phenomena which have been described to us this evening. From my experience in these places I do not feel justified in supposing that there was a greater body of water in olden times than there is at present.

Mr. STIRRUP: There is one thing I would wish to say, the Society is very much indebted to Mr. Bowler for the loan of his lantern, and to Mr. Leach for his kind assistance this evening. The least we can do is to give these gentlemen a hearty vote of thanks. All they require at our hands is an appreciation of their services. You will, I think, agree with me that we have had a very good lantern exhibition, and the slides have been presented to us in a very masterly way.

Mr. SOWERBUTTS: Whilst expressing the very great pleasure with which I have listened to the address, I would like to say that the members of this Society will make a great mistake if they do not study very carefully the admirable monograph which Mr. Stirrup has placed upon the table, "Les Cévennes et la Région des Causses, par E. A. Martel." I have rarely got hold of so fascinating a book. I am sure Manchester has been very fortunate indeed in having got from the author of the book these lantern slides, which are authentic, and the book itself, which is remarkably well written. How they can produce in France a book like that for five francs I do not know. We get nothing like it in England for the money. I wish we could have monographs published here in the same brilliant style.

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Mr. STIRRUP said he wished, before the meeting separated, to say that the galleries of the museum, including that which contained the Egyptian antiquities, were open to inspection, and the members were invited to see them.

The CHAIRMAN: I would just like to say also that there is a collection of objects in the Geological Museum which illustrate the phenomena described in the paper, which I have been engaged many years in collecting. I may say to those gentlemen who have not been able to lay hold of the monograph, that if they will refer to a book I published about 18 years ago—"Cave Hunting"—they will find a description of the principal points which have been put before us this evening—relating, of course, only to this country.

The meeting then separated.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XX. SESSION 1889-90.

The ORDINARY MEETING of the Members was held on Tuesday, February 11th, 1890, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, HENRY HALL, Esq., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

JAMES MC.GEEVOR, Garswood Hall Colliery, Wigan.

ALFRED E. WEBSTER, Mining Engineer, The Wigan Coal and Iron Company, Limited, Wigan.

ILLINGWORTH LAW, Mining Engineer, Waterfoot, near Manchester.

RICHARD BURROWS, Mayfield Road, Eccles.

MAUNSELL MERCIER, King Street, Wigan.

Mr. STIRRUP (Honorary Secretary) drew the members' attention to some recent additions to the Society's Library, lying on the table, which included a series of Memoirs of the Geological Survey of Great Britain, relating to the Northern Counties, which had been purchased. These, he

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said, would be found extremely valuable for consultation. There was also a large number of works from American and other Corresponding Societies, which deserved attention.

Mr. STIRRUP went on to say: Since our last meeting in these rooms we have lost, by death, one of our members, Mr. Daniel Adamson, a gentleman whose name and fame is known to all of you. He was elected a member in 1877, and who, although he was not able to devote the time to attend our meetings, nevertheless, I know, took a great interest in the proceedings, of which he gained a pretty accurate knowledge from the perusal of our Transactions. It will also be remembered, as a proof of his interest in the Society, that he, some eighteen months ago, invited us to visit the Lincolnshire iron-fields, and the iron-works which he had established, now belonging to the North Lincolnshire Company. Those members who were present on that occasion will remember the very hearty reception they got from Mr. Adamson, and will also recollect the characteristic address which he gave after the luncheon, an address which showed that he possessed a sound knowledge of the fundamental principles of geology. I think it is our duty, on this, the first occasion that has presented itself since his death, to pass a vote of condolence with his widow and family. I, therefore, move that it be an instruction to the Hon. Secretaries to forward a vote of condolence to Mrs. Adamson and family.

Mr. DICKINSON seconded the motion, which was unanimously carried.

Mr. STIRRUP called attention to a pamphlet ("Extract. Ges. Isis in Dresden) which had been sent to him by

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Mr. C. Roeder for the Society, in which Professor Geinitz, of Dresden, gave the results of his examination of a collection of fossils from the Permian beds of the Manchester district. A cutting had recently been opened near Stockport, and some fresh fossils there picked up, which had, with some older species, been sent to Dresden. Dr. Geinitz had gone through them and had published a little paper upon them, entitled "Ueber die rothen und bunten Mergel der Oberen Dyas bei Manchester," which, so soon as he (Mr. Stirrup) had opportunity, he would translate into English, and read at a meeting of the Society, in order that it might appear in their Transactions, with some addititional remarks from Mr. C. Roeder.

"STIGMARIA FICOIDES" FOUND IN A MINE AT OVER DARWEN, LANCASHIRE.

By Mr. Richard Walkden.

The fossil that I have the pleasure of bringing before the Society to-day was found at Messrs. Ralph Entwistle and Co.'s Cranberry Lane Colliery, Over Darwen. The mine being worked at this colliery is commonly known in the district as the Lower Mountain Mine, or Seventy Yards' Mine, and is also called the Half-Yard Mine; but it is the seam lying between the Lower Foot and the Yard or Mountain Mine of this district. The floor of the coal seam is a workable fireclay, and the floor of the fireclay is a very hard gannister rock, and the fossil was found at about 73 yards below the surface of the ground, three-parts buried in the fireclay and one-part in the gannister rock, but lying

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parallel with the dip of the strata. The strata at that part dip at the rate of 1 in 11, and the fossil lay along the direction of the greatest dip, with the pointed end lowest. It is about 16 feet long, and somewhat elliptical in section, the long axis of the ellipse measuring three to four inches, and the short axis two to three inches; but about six inches of the end that lay furthest from the trunk is tapered and pointed. There is a groove running along the major part of its length, and the fossil is indented with shallow roundish holes over a great portion of its surface. The trunk to which it was attached was 30 inches in diameter, but owing to it being almost embedded in the hard rock, and the very awkward and confined situation, I am sorry to have to say that I could not get the trunk out. I found parts of other roots which appeared to point towards the trunk. The substance of which it is composed looks much like fireclay impregnated with a little iron, but the outer surface is somewhat black and is smooth.

Mr. James Grundy said: I did not see this specimen *in situ*, but on seeing a portion of it at the colliery I encouraged the Manager to try and get it out if possible. You will appreciate his difficulties when I say that in the part where the fossil was found the coal had been cut out for a considerable time, and he had to explore a spot where the roof had given way. He followed it in the fire-clay as far as he could, getting piece after piece out, until he came to the root itself, or central stem, which was found to be about 30 inches in diameter each way; but the rock being so hard, and the root in such a confined situation, it was impossible to get it out.

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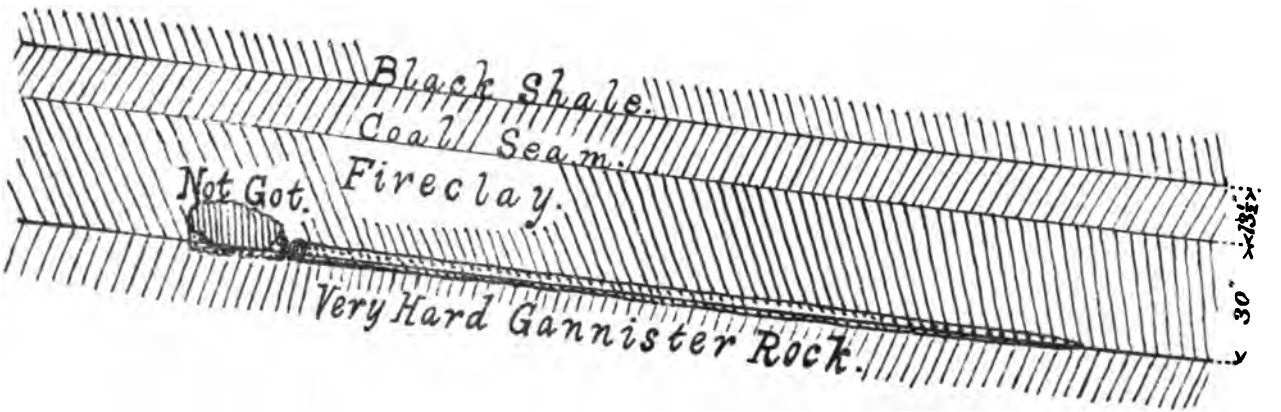
Trans. Man. Geo. Soc. Part XVII. Vol XX.
To illustrate Mr Richard Walkden's Paper

STIGMARIA IN MINE AT OVER DARWEN, LANCASHIRE.

73 Yards below surface.



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Mr. STIRRUP: I think we are very much indebted to Mr. Walkden for exhibiting this specimen, which, as we have heard from Mr. Grundy, took so much trouble to procure. It is a fine specimen of a branch of a stigmarian root, which, though longer than any of the root branches of the large stigmaria now to be seen at the College, is shorter than that which Professor Williamson measured in the ground at Messrs. Briggs quarry near Clayton, Bradford, in Yorkshire, which was found to be upwards of 37 feet from exterior of base of central stem to tip. The specimen before us is interesting from the circumstance that the markings upon it are clear throughout its whole length, and that it has retained its original cylindrical shape to the terminal point. In many cases the roots are so crushed and compressed that we do not get their markings, which are simply the scars left by the little rootlets which have spread all around into the clay. These rootlets of course are gone, though you find them often disseminated through the fire-clay. The clearness of the scars, I take it, may mean that this has been the root of a younger tree than the large example to be seen at the Owens College. As the tree gets older no doubt these markings become more effaced. I would like to ask Mr. Walkden if he is willing that this specimen should be given to the Museum.

Mr. WALKDEN: It will give me very great pleasure to do so.

The PRESIDENT: Has it drifted, or does it belong to the stratification in which it was found?

Mr. STIRRUP: My view is that it is the root of a tree which has grown upon the spot where it was found, as shown by the sketch of its position in the strata. There are no doubt other branches of the root *in sitû*, but from the difficult position they could not be got at.

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Mr. WALKDEN: There were a few more pieces visible, but nothing like this.

Mr. STIRRUP, in reply to an observation of the President, said the filling of the specimen was evidently of the same material as the fire-clay bed and not ordinary sandstone.

On the motion of Mr. STIRRUP, the best thanks of the meeting were given to Mr. Walkden and Mr. Grundy.

Discussion on Professor Hull's paper, read at the December meeting,

"ON THE PROBABLE DEPTH AT WHICH COAL IS NOW BEING WORKED IN THE BRITISH ISLES."

Mr. GASCOIGNE (Ashton Moss,) in opening the discussion, said: I happen to have passed considerable time in Yorkshire, Nottinghamshire, and Derbyshire, and am pretty well acquainted with all the collieries in those counties. I noticed, when this subject was previously discussed, that it was pointed out that the depths of the shafts in colliery districts do not bear any reliable relation to the depths at which coal is worked; and find in Mr. Hull's paper the deepest colliery working is given as 700 yards. Now at the Thrybergh Hall Colliery, which is in the same royalty as the one at which I was working before I came into this district, the depth of the shaft was about 200 yards, but they are working the coal at a depth of 975 yards. The measures dip from the shaft about 17 inches to the yard. Such a depth, I noticed, was not mentioned at all in the paper. Then there is the Kiveton Park Colliery, which has been sunk down to the Silkstone Coal, a depth of 800 yards.

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Mr. DICKINSON: Is not Kiveton Park in Yorkshire?

Mr. GASCOIGNE: Yes; and so is the Thrybergh Hall Colliery; but Mr. Hull's paper refers to Nottinghamshire and Derbyshire, and I believe also to the Yorkshire coal field. I may say it has fallen to my lot to be engaged at a colliery where they are working coal at over 1,000 yards deep, and we do find there a difficulty in keeping the workings thoroughly ventilated—I mean as regards being comfortable. It seems to me that where the temperature gets above 85° it is necessary to have very short splits in the ventilation in order to keep the workings in a condition which shall be comfortable for the men. My object in rising was to point out to you that there are in Nottinghamshire, Derbyshire, and Yorkshire, collieries working at greater depths than those spoken of by Professor Hull in his paper. There are seams dipping at higher angles than are generally supposed by people outside the district.

The PRESIDENT: What do you consider the ultimate depth, or the highest temperature at which men could reasonably be expected to work?

Mr. GASCOIGNE: I am not quite in a position to state. It depends much on circumstances. The temperature does not always increase in proportion to the depth. For instance, I know a colliery 600 yards deep, where the temperature is 86°, and there are collieries 900 and 1,000 yards where the temperature does not exceed 86°; but I do certainly think that at 1,000 yards the colliers do not seem to be able to do the same amount of work which is possible at 500 yards depth. That is the conclusion I have come to. You will find in a stall with a seam the same thickness, and with other conditions the same, such as length of stall and facilities for getting coal, that at 1,000 yards below the surface the men

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do not get as much coal as they will do at more moderate depths. I may say that our stalls are 40 yards long, and some of our men do not get above 30 tons per week, and 50 tons is a fair get for one of those 40 yards' stalls; so that I think the temperature has already, at 1,000 yards depth, begun to show some effect upon the tonnage of coal to be worked from those stalls.

Mr. TONGE: May I ask how many men are in those stalls?

Mr. GASCOIGNE: There are four men in each 40 yards' stall.

Mr. TONGE: So that the four men would only send up 30 tons a week amongst them?

Mr. GASCOIGNE: Of course some men can send more than others, but 50 tons seems to be about—well, I will call it a fair output from a 40 yards' place at a depth of 1,000 yards.

Mr. TONGE: What thickness of seam?

Mr. GASCOIGNE: Three feet eight inches.

Mr. DICKINSON: Since the publication of Professor Hull's paper in the *Transactions*, with the discussion which took place upon it, I have had a letter from the Professor in which he says that from some observations that were made, the object of the paper was apparently not sufficiently understood. The letter is as follows:—

Geological Survey of Ireland,
Office, 14, Hume Street, Dublin,
10th February, 1890.

Dear Mr. DICKINSON,

I observe that in the discussion which took place at the meeting of the Manchester Geological Society on my paper on "The Probable Average Depth of British Coal-mining,"* some uncertainty was expressed in reference to the object of the paper itself. I, therefore, ask permission to say a few words in explanation.

* Transactions, Vol. XX., p. 420.

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I think it will be clear on consideration that if there really be a physical limit to the depth at which coal can ultimately be worked, that limit will not be determined by the workings of one colliery here, or another there. Some collieries, from the peculiar excellence of the coal seam itself, or from its thickness or other causes, may be able to extract coal at depths beyond the generality of mines. For this cause, when we speak of the limit of workable depth, we speak, not of any individual coal-working, but of coal-workings in the aggregate, and this is to be measured by the average depth, or *depth of maximum coal-production*. This is what I was aiming at in my paper. The system adopted in Belgium which you describe seems calculated to allow this question of average depth to be very accurately determined; and as regards the difference of levels at which the same seam is worked in British mines, it is probable that where the coal is worked both above and below the level of the shaft, the depth of the shaft itself would be found a sufficiently close approximation.

Yours faithfully,

EDWARD HULL.

You will (Mr. Dickinson continued) recollect that in what I said I gave an instance of one colliery where a part of the workings in the same seam was actually 400 yards deeper on the dip than it was on the rise, and that there was no coal—or little, if any coal—being worked on the rise of the pit shafts; so that there you have a variation of 400 yards from the pit shaft without anything to counterbalance it.

Mr. CLAY: The colliery with which I am connected at Dukinfield is the Black Mine, and I have made it my study to ascertain the amount of coal a man can get. The temperature in working places runs 81°, 82°, and even 90°, and in a temperature of 81°, in the Black Mine, two men can get 16 tons a day, that is at 986 yards vertical depth from the surface. In the Cannel Mine, 50 yards below, the cannel runs from 30 inches to 5 feet thick, and I have seen the same quantity got there. It must be said, however, that the coal is not hard.

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The PRESIDENT: Will you kindly give us your views on the question—speaking from your experience in that deep mine—at what temperature does the men's day's work begin to be affected?

Mr. CLAY: I think it is affected if the temperature is above 83°. But the most laborious work, in getting coal, is not where the pit is so deep. In our Astley deep pit the men can get even more coal than they can in the Roger Mine.

The PRESIDENT asked at what temperature they could keep the men working.

Mr. CLAY: From 82° to 84°.

Mr. GASCOIGNE: When I spoke of the small output per stall, I was comparing it with a colliery I know where the seam is the same thickness, and the coal similar in quality, taking about the same amount of labour to get. There they got 100 tons per week in a 40 yards' stall. But I am speaking now of the Ashton Moss Colliery, where they get only 50 tons per stall at a depth of 1,030 yards.

The PRESIDENT: 100 tons as against 50.

Mr. GASCOIGNE: Yes; 100 tons at the lesser depth and 50 at the greater. I believe our Black Mine coal is more difficult to get than the Dukinfield. It is scarcely so thick for one thing, and there is more roof to move and to break down.

The PRESIDENT: I think, gentlemen, from what has been said by the members who have spoken, that there is no doubt we are approaching the depth at which the men will send up a smaller quantity of coal than they do at present from depths which are not so great, and I should just like to mention one or two little matters that have some bearing upon this point. I see that Professor Hull has

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read a paper in Edinburgh since our last meeting, and he there states that the duration of our coal would be something like 1,000 years, or over 1,000 years. From this it would appear that he must assume that we shall be able to work coal at much greater depths than mining men have ever thought it would be practicable to work, or else he must underrate the demand for coal. Well, personally, I do not see any reason to assume that our successors should be less anxious to produce a large quantity of coal than we ourselves. Professor Hull may think that there is no means of producing a larger quantity, but if you bear in mind that at the present time the coal-pits of the country only draw coal about nine hours a day, I do not think there is much to fear from that difficulty. If the pits were all put on 24 hours a day, and there was a demand for the coal, our coal-fields would be exhausted in something like 300 years, as stated in my address at the commencement of the session. Since our last meeting I have had a communication from Mr. Whittaker, in which he states that with regard to the coal-field or supposed coal-field in the South of England, they are trying to raise funds to put down a deep bore-hole, in order to tell whether there is coal there, once for all. So that there is now an opportunity for anyone who holds the opinion very strongly that there is coal there, to subscribe to that fund. There is one other point which I think will be of interest to geologists, it is as to whether the coal exists on the site where the trees grew or whether it has drifted into that position. I understand that most English geologists hold that coal is now found on the site of the carboniferous forests. There was an interesting paper read by Mr. Sawyer, of the Midland Institute, on the South African coal-field, in which he says, that appearances are against the view that

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the coal has grown in the position in which it is found. Some other gentlemen have written to me, amongst them Mr. Galloway, a deep thinker and close reasoner, and he holds the opinion very strongly that, with few exceptions, the coal deposits were drifted into the positions in which we now find them. He believes that geologists will have to give up part of their faith in the theory that coal is now found on the site of the forests to which it owns its origin.

Mr. OLDHAM, in the course of a few remarks, said that in a paper he intended to read before the Society, he had no doubt he should be able to solve the whole difficulty.

Mr. STIRRUP: Our President has opened up a very debateable question, namely, as to whether the coal-fields are the result of drifted vegetation or the product of vegetation grown on the spot: that is a question which I fear at this advanced period of the afternoon it will hardly be possible for us to discuss. I, for one, have my own views on that question, but I think it would not be well now to enter upon the discussion.

Mr. BRAMALL said: We are working, at Pendleton, about 1,000 yards below the surface—the greater part of the workings in that colliery run from about 850 to 1,000 yards vertical depth; but we have not found, taking the mine all through, that the men do any less work than is done in the same mine at lesser depths. Of course there is a great difference amongst the men. We have sets of men who apparently without any reason—except that they are better men—send up double the quantity of coal that others do. It all depends on their skill in working. But taking the average, although the temperature is 85° to 87°, we do not find so great a difference that they cannot do the same amount of work as in other workings of the same mine,

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where the depth is not so great. It all depends on the way in which the weight is dealt with.

Mr. GASCOIGNE: Our depth is about 1,030 yards, and we are now commencing to open out mines lying deeper still. I am unable to say what the temperature will be as we get lower down. I have not had an opportunity of testing what the temperature is at Ashton Moss Colliery. We have thermometers here and there in the workings, but as they will be affected by the atmosphere of the mine I cannot give you the temperature of the strata. I have, however, a thermometer sent me by the British Association for taking the temperature of the seams. I will make use of it and let you know what the results are. I am sorry that my experience at Ashton Moss does not seem to agree with that of other members of the Society, but I have been there only a short time, and the fact mentioned should be borne in mind, that there is a great difference in men. Perhaps when I have been there longer I shall be able to form a better idea of the effects of temperature on the amount of work a man can do at these different depths.

THE SALT DEPOSITS OF THE UNITED STATES OF AMERICA AND CANADA.

With Notes of a Visit to the most important of them.

By Mr. THOMAS WARD, J.P.

Having been sent out in the summer of 1889 to report on the chief salt works of the United States and Canada, I had an opportunity of visiting the most important salt deposits in North America. My object being more particularly to

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inspect the manufacture of white salt, and my time being very limited, I could not give that attention to the geology of the salt as I otherwise should have liked to have done. In the space of three weeks I travelled over 4,000 miles of territory, and inspected over 50 sets of salt works, so my leisure for studying geology was very little. By dint of enquiries, and by noting carefully the physical features of the country through which I passed, I gathered a good deal of interesting information.

Until quite recently salt was known to exist in but few of the States. Brine had been known, and salt manufactured for over a century at Syracuse and Onondaga, in Central New York State; but it is only within the last year or two that rock salt has been discovered at Tully, a short distance to the south of Syracuse. The discoveries of rock salt in the valleys of the Wyoming and Genessee rivers, in Western New York, have been made within the last 10 or 12 years. In Canada, rock salt was found a little more than 20 years since; whilst the enormous deposits in Kansas have been discovered less than three years. The wide-spread deposits of Michigan have been gradually discovered and brine pumped during the last 30 years. The remarkable deposit of rock salt on Petit Anse Island, in Louisiana—not far from New Iberia, was found in 1862. Rock salt has been known to exist in Arizona for some short time, and in Utah. In West Virginia, South Ohio, and Pennsylvania, salt has long been known to exist. It is only since boring for petroleum became so common that rock salt has been extensively discovered. During the last 30 years more deposits of rock salt have become known in all parts of the world than in all previous time.

In the year 1886, I had the privilege of reading a paper

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before this Society on "Rock Salt."* The views then put forward have been corroborated by all I saw and heard in the American salt districts, and one of the shrewdest American salt manufacturers, Mr. Thomson, of St. Clair, Michigan, expressed views in all respects similar to my own, after carefully considering the question.

I left New York on the night of June 3rd, 1889, and on awaking in the morning found the train stopped on the borders of New York State, the railway track having been washed away by floods of almost unprecedented severity. We were in a river valley, and the country around was very pretty. The valley of the Chemung River, through which we had to pass, was one scene of desolation caused by the floods, and our progress was very slow indeed. Repeated stops for repairing the track, or for bridging streams whose bridges had been washed away, gave us a good chance of looking at the scenery. This portion of New York State reminded me very much of Derbyshire and North Wales, only that the rivers and valleys were larger. Finding ourselves at the close of the day many miles from our destination, with broken bridges and wrecked railway tracks, we left the main line at the pretty town of Avon and took a small railway which landed us at a very pretty town called Geneseo, in the immediate neighbourhood of which we first came on the salt.

Geneseo lies on the slope of the highlands, over-looking the Genessee River. The scenery is beautiful. Looking from the balcony of the Big Tree Hotel, we had a most extensive view of the flat lands of rich alluvial soil, bordering the Genessee River; and the rising land, beautifully wooded,

* "On Rock Salt." By Thomas Ward. Read before the Manchester Geological Society, January 26th, 1886.

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which stretched for miles on the other side of the river. On this flat land and on the rising ground, are the Salt Works of the Genessee Salt Co., and Livingstone Salt Co., at Piffard, and the celebrated Rock Salt Mine, called Retsof, *i.e.*, Foster reversed.

On June 5th, we started from Geneseo, and crossed the Genessee River, still in full flood. In driving for a distance of a mile or more over the flat lands, our carriage was sometimes up to the axles in water, sometimes in mud. These flat lands are considered some of the most fertile in the State, and the celebrated Boston bean is largely grown on them. The Genessee, like most streams in a flat country was very winding, and the floods had washed over at the various bends, carrying with them hundreds of trees and logs, and tearing up and washing away scores of acres of the newly planted beans and the alluvial soil in which they were growing. The power of water for tearing up and transporting trees was well shown, as also, its denuding force when in contact with light soils. After seeing the destruction wrought in all the river valleys, and the wash-outs and destruction of roads for miles round, I had a clearer conception of the power of water in carving and altering the face of the earth. My three days in the valleys of Western and Southern New York State, taught me many lessons in denudation and erosion.

The beds of rock salt in the Genessee Valley are met with from 800 to 900 feet from the surface. The system of boring adopted is an excellent one for commercial purposes, as the boring is soon made; but it is quite destructive of all cores, and prevents a very accurate knowledge of the strata being obtained. I had the utmost difficulty in getting any reliable information. Fortunately, borings have been made

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in many other parts of New York State, and a general knowledge of the order of the different strata has been obtained. I am deeply indebted to Dr. Engelhardt, of Syracuse, for much information respecting the salt deposits of New York State. He kindly gave me a copy of his report, made to the Superintendent of the Onondaga Salt Springs in January, 1889. This did not come into my hands until I had finished my inspection; but it is very valuable in calling to mind what I had seen, and in supplying a mass of details as regards the various borings for salt made in the State. From the data furnished by this report, compared with the notes made by me from information on the spot, it will not be difficult to come to a conclusion as to the position of the salt beds in New York State. I am not conversant with the names applied to the various geological formations in America, but I shall be able partly to overcome this difficulty by the help of a pamphlet sent to me some years ago by Professor Sterry Hunt, of Canada.

To prevent dealing with the same subject several times over, I will proceed with my tour, and complete my inspections in New York State.

I visited the salt works of the Genessee Salt Company and the Livingstone Salt Company, both at Piffard, and having been entertained to luncheon by a son of General Wadsworth, a most agreeable gentleman,—who kindly pointed out the various natural objects of interest in the immediate neighbourhood,—I proceeded to the only important rock salt mine in America, viz., the Retsof, or Foster, named after a New York gentleman, a large shareholder in the mine. I regret very much, that, not having been able to communicate with the principals, I was unable—owing to a very stringent rule in force—to descend the mine. Nothing, however, was lost by this, as I am well acquainted with

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rock salt mines; and knowing the geology of the district, and seeing the salt as brought to the surface, I was able to satisfy myself on all questions that interested me. The rock salt is of a greyish colour, being in a light coloured limestone district, and not of a reddish brown like our English rock salt. It is sent off in large lumps for cattle, and ground and used for refrigerating and curing purposes. Since this mine has been opened, the use of rock salt has enormously increased in America. As I found the officials reticent on some points, I walked round to inspect the waste and refuse salt lying in the neighbourhood of the mine. I found what I was looking for, and had my opinions as to the origin of rock salt corroborated. Far more is to be learned from a lump of refuse salt,—that is, one where earthy matter predominates,—than from the purest salt crystals. I have brought the lump of salt which I found, and you will notice the thick layer of marl attached to the salt. The regularity of the surface shows that it was a deposit from the flood-water brought into the salt lake in which it was formed. There appeared to me an absence of the large perfectly transparent crystals which are met with in English rock salt, and the salt itself seemed more easily broken up. The specimen of rock salt may be taken to represent most American rock salts, especially those found in New York, Canada, and Michigan.

Returning to Geneseo and its hospitable hotel; the next morning I set out for a long drive over the lands bordering the Genessee. This part of New York State is very pretty. The river cuts its way through slaty rocks, and runs through deep gorges of the most picturesque description. Descending I reached Mount Morris, another salt town close to the Genessee River. The rock salt here lies at a depth of over

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1,200 feet. Crossing the Genessee by a long wooden bridge, over which rapid driving is prohibited under penalty, as in other parts of America, I scaled the highlands and reached a plateau about 1,500 feet above the sea level. The day being gloriously fine—the scenery beautiful, and population very scant—the drive was of the most enjoyable kind. At one part of the road we descended to look upon the Genessee running through a deeply cut valley, with precipitous slaty rocks. The scene was one not to be forgotten In all places, except where the bare face of the rocks prevented, the banks were covered with pine trees, and where the valley widened out now and again, beautiful meadows of rich alluvial soil seemed spread out like a carpet. Descending rapidly, a little salt town called Perry was reached, at the outlet of a pretty little lake known as Silver Lake. The rock salt here was over 2,000 feet deep, and the slatey rocks came to the surface. These rocks are over 1,400 feet thick, and had been bored through to reach the salt. The owner of the salt works made cider, and his cellars were hewn out of the solid slatey rock of the district. Leaving Perry, and driving alongside Silver Lake, and hence further south, we reached Silver Springs or Gainesville, and here the rock salt was 2,124 feet from the surface. At Castile, not far distant, which I was unable to visit, the salt was reached at a depth of 2,370 feet, being the deepest salt boring in New York State. The salt works of Duncan & Co., at Silver Springs, were very interesting. I proceeded by way of Rock Glen Salt Works, where the salt was 2,015 feet from the surface, to Warsaw. The country was very scantily populated, and the roads, which frequently crossed railway tracks, very poor, as they are generally in America. They were especially bad at the time of my visit, having been literally washed

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away by the very heavy rains and floods. It was extremely difficult in places to drive at all, and we were pleased to reach Warsaw, the great centre of the salt manufacture of Western New York State.

We were now in the valley of the Wyoming river, which is not so wild and beautiful as that of the Genessee, though pretty. Warsaw lies in the valley, but the salt works are on the hills on either side. The reason for this is that the Wyoming, like the Genessee, is not navigable, and the railway lines are carried along the sides of the hills. It would be useless to put the salt works on the low ground; so, for convenience of railway carriage, they are alongside the lines. The salt works extend for a considerable distance on both sides of the Wyoming. The salt in the most northerly of the works visited, the Crystal Salt Co.'s, at Saltvale, Wyoming, was 1375 feet from the surface, whilst at the Eldridge Salt Co.'s the most southerly on the west side of the Wyoming, it was 1975 feet. As a rule, the northerly salt works have the salt lying nearest the surface, whilst the southerly, owing to the rise of the surface towards the highlands of the Genessee, have the deepest salt. At Leroy, the most northerly of the salt works in the Wyoming valley, salt is found at 610 feet from the surface, whilst as we have seen at Castile the depth is 2370 feet. The rise in the surface will scarcely account for all this difference. It would seem as if there was a slope of the salt surface downwards from north to south. I was in hopes that I should have procured a map by Col. Mc.Clure showing this, but I have merely got one on a large scale, showing the Western New York Salt District.

No rock salt is mined except at the Retsof Mine, and no shafts are sunk for brine. In fact, I did not meet with

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a single brine shaft in the whole of America. Borings are put down to the rock salt. The usual borehole is 5 inches in diameter, and the pump for raising the brine about 3½ inches. In most cases it is necessary to put water down these boreholes to form brine on the rock salt at the bottom. Where this is done a double tube is required. In some cases the water is forced down at a pressure of 160lbs. to the square inch, and this pressure forces up the brine without any pump being required. I will not stop to describe the process of manufacturing white salt at Warsaw and the other places. It is a most important industry, and has sprung up in the last ten or twelve years.

I left Warsaw for Niagara Falls, and spent the week end there on my way to Michigan. It would make my paper far too long to attempt to describe fully this great wonder of nature. For a geologist it is a school where many lessons are taught. Not only are there splendid rock sections exposed to view, but here, on the most gigantic scale, nature can be seen at work cutting and carving the rocks, and hewing out a stupendous gorge by the ceaseless, unrelenting power of the mighty stream. Standing on the Canadian side we can see that the American Fall comes over the side of the gorge; whilst the Canadian or Horse Shoe Fall is the main stream cutting back the rocks and forming the gorge. The island lying between is cut up by minor streams. The great wasting of rock takes place on the Canadian side, near the shore. The ceaseless fall of the large body of water deeply impresses every thoughtful mind. A journey down the stream from the falls, past the rapids, to the whirlpool, shows the erosive effects of water, and gives some idea of the immensity of time required to have eaten away such a deep gorge through the rocks. When again

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we find these rocks to be geologically old and overlain in the interior by hundreds of feet of rocks of various kinds, including the saliferous that I have been speaking of, the enormous age of the world may be imagined. The Genessee river, whose beautiful gorges I previously mentioned, had, in producing these, cut its way through rocks several geologic ages later than the Niagara limestones. The mind is incapable of grasping the time required to do all this cutting and carving. The mighty power of water is splendidly shown in North America.

I left Niagara Falls in the night and passed rapidly through Canada over a rather flat country to Detroit. The train was ferried over the River St. Clair connecting the Lakes Huron and Erie, with Lake St. Clair between them. I had now entered Michigan, and proceeded to the St. Clair district, lying between Lakes Huron and St. Clair. Here I came upon salt and salt works once more. The towns of St. Clair and Marine City are the chief centres of the salt, though it is found for fully fourteen miles along the banks of the river. It is also found on the opposite bank in Canada. The enormous area over which the rock salt formation extends is very remarkable. From the Walton salt works, near to the head of St. Clair lake to Oscoda on the shores of Lake Huron in northern Michigan, there are salt works extending at intervals over a line of more than 120 miles. If we look at a map of Michigan and that part of Canada lying along the St Clair river and the East shores of Lake Huron, we shall find salt works from Courtwright in Canada, opposite St. Clair in Michigan, to Kincardine on the shores of Lake Huron, nearly opposite to Oscoda. On Lake Michigan at Luddington and Manistee, about as far north as Oscoda and Kincardine, salt is found and salt works have been established.

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I spent a most enjoyable day in visiting the whole of the salt works on the St. Clair river, from St. Clair in the north, *via* Marine City and Algonac, to the Walton works, near the head of St. Clair lake. The country is flat as also is Canada on the opposite banks, but the river is a splendid one, of great depth and with beautifully clear water. The whole of the lake traffic from Superior, Michigan, and Huron passes through this river on its way to Lake Erie and the large American cities on its shores.

The rock salt in the St. Clair district is met with about 1,600 feet from the surface, and the water of the St. Clair river is forced down the boreholes. The brine is some of the best in America. It would take up too much time to describe the salt works and methods of working them. In this valley at the Oaklands Hotel, which is a splendid wooden erection and a favourite summer resort, is the spring from which is obtained the noted Salutaris water. The short time spent in this district has left very pleasant remembrances.

Leaving St. Clair, by one of the Lake Steamers, I proceeded to Port Huron, opposite to which on the Canadian shore is Sarnia. A ferry connects the two towns. Taking the train at Port Huron, which lies at the junction of the St. Clair River with Lake Huron, I had a journey of about 90 miles through the pine woods of Michigan to East Saginaw. It was a single-track railway, and the novelty of passing through nothing but pine woods, with here and there a clearing for a station or a lumber camp, was quite exciting. The country was flat and the soil of a sandy nature. For miles, in some parts, the woods had been devastated by the forest fires which are so destructive, and nothing but the charred trunks of the pines were left standing in countless

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thousands, like so many black telegraph posts without wires. After a destructive fire, it seems that the pines do not again grow; but their place is taken by other woods, called hard woods, and not so useful to the lumberers. It would seem as if the great pine age was passing and was about to be followed by that of birches and similar woods. This fact, which was pointed out to me by a fellow traveller, reminded me of the different periods of oak, beech, pine, &c., shown in the peat bogs of Denmark. It seems difficult to understand the nature of the change; but in journeys of over 160 miles through the pine woods, wherever a clearance had been made by the fires, no young pines were observable, though, plenty of other trees were springing. Even where the lumberer's axe had been busy, only the stumps remained; no young pines could be seen. Ere many years are past, the enormous pine woods of Michigan will have been cut down and sawn into planks. The pine wood districts are only very scantily populated, and after clearing, the land is not fertile enough to attract agriculturists. Saginaw City and East Saginaw are on the Saginaw River, which enters Saginaw Bay, on Lake Huron, at Bay City. When I arrived at East Saginaw, I found myself in a very handsome bustling city, the centre of the lumber trade. Here again, I came upon brine and rock salt. The brine is found at about 1,000 feet from the surface, and is not very pure. Salt is made more cheaply here, than in any part of America, owing to the exhaust steam of the saw mills being used. From Saginaw to Bay City, a distance of 14 miles, the river banks and the neighbouring low lying land are lined with saw mills; and the river itself and the ponds along the margin are full of floating logs ready to be sawn up, whilst on the quays and landing places are huge piles

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of boards and planks ready for shipment. I visited a number of these huge saw mills, and inspected them and the salt works attached to them. The slabs sawn from the trees together with the sawdust, serve for fuel, and the steam having done its work in sawing, is turned through pipes laid at the bottom of huge wooden salt pans, averaging 120 feet in length by about 11 in width, to make salt. The bustle of a lumber mill, and the utilization of all waste products, impressed me very strongly with the go ahead character of the Americans. Having inspected the Saginaw River district, I proceeded *vid* Bay City to East Tawas, on Lake Huron, in Northern Michigan, another ride of 75 miles through pine woods, similar to those between Port Huron and East Saginaw. The country was similar in its nature to that already described. East Tawas and Tawas City were lumber towns pure and simple. The woods came almost to the shores of the Lake, and the lumber mills and salt works were on its shores. Vessels came up to the quays and loaded lumber or salt. The salt lies about 800 feet from the surface, but the brine is not very strong. When staying at Tawas, I drove a short distance into the heart of the woods, to look at a small set of salt works, and some brine wells, or borings put down to supply the salt works at Au Sable and Oscoda, some 11 or 12 miles further north. The shores of Lake Huron were low lying. I had a beautiful sail on the lake towards Au Sable to see a raft of pine logs which had been towed by steamer from Canada, over 200 miles away. There were logs in the raft that would cut up into 3,000,000 feet of 1in. board a foot wide.

The days spent amongst the pine woods, lumber-mills and salt works of Michigan were very enjoyable though fatiguing. I left Michigan for Kansas, and returned to

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Canada, but as the Canadian salt district lay along the St. Clair River and the banks of Lake Huron, I may as well finish my remarks on Canada before touching on Kansas.

The salt works of Canada are chiefly in the neighbourhood of Seaforth, Goderich, Clinton, and Kincardine. The rock salt varies from 900 to 1,700 feet from the surface, and is in the same formation as the New York rock salt and brines. No rock salt shafts are put down in Canada. At Goderich some of the works are on the banks of the Maitland River, and others on the bluffs overlooking Lake Huron. These bluffs rise some 60 to 100 feet above the lake, and being composed of alluvial soil or clays are being rapidly eaten away by the waters of the lake. The salt works are carried on differently to those in Michigan, there being no pine forests in the neighbourhood. Plenty of other woods however abound the timber of which is used instead of coal, or in conjunction with it in the manufacture of salt. This part of Canada looks very English, and the farms seemed better cultivated and cared for than in most parts of America. On the whole there was a flatness and tameness in the scenery unlike some parts of New York State. I proceeded from Michigan to Chicago by rail, instead of across the country to Luddington and Manistee, on Lake Michigan, where salt is found similar in all respects to that in Eastern Michigan. My colleague left me at East Saginaw, being ill, and returned to New York, where unfortunately he died suddenly. Having been practically working night and day for some time, I preferred leaving the Manistee section of country out. From Chicago, where I only spent a few hours, I started for Kansas City, a ride of 489 miles. I passed over this portion of the country during the night. Kansas City was reached in good time

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in the morning, and also the "Mighty Missouri" or "Big Muddy" as it is locally called; its stream being nearly always pretty well charged with mud from some of its tributaries. Kansas City has an imposing appearance, when seen from across the Missouri, standing as it does on high bluffs. The city has now a population of 160,000, and seems one of the busiest and most thriving cities in America. Leaving Kansas City, after about a two hours' stay, we proceeded to Hutchinson, 235 miles across Kansas State, in a W.S.W. direction. This was my furthest West and South, and was only about 100 miles from Oklohama, in Indian territory, and not far from Northern Texas. The country was flat almost the whole way, with now and again low limestone bluffs. There were but few trees, and these almost always along the banks of the streams. Indian corn and wheat, but chiefly the former, were grown most extensively; and herds of fine cattle were grazing in the enormous pastures through which the railway ran. We had an instance of the use of the cow-catcher on American engines, when a herd of cattle strayed on the railway. Our engine struck one, and turned it over into a ditch, where it lay with a broken neck. We arrived at Hutchinson, on the banks of the Arkansas River, in the evening. The country around was very flat, and the Arkansas River wound its slow way along, amongst countless sandbanks; the water in no place being deep enough for navigation, though the river was half a mile wide. Fifteen years ago the country was prairie land, and the wild buffaloes rambled over where now stands Hutchinson, a town of 15,000 inhabitants, with a main street wider than any street in Manchester, with splendid shops, electric lights for the streets, telephones generally used, and tram cars, with double lines in the main street.

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I was now in the midst of one of the largest American salt deposits, which was only discovered as recently as 1887. I visited some eight or ten sets of salt works more than half shut down, and found salt nearer the surface than in any other part of America visited by me, and of great thickness, varying from 100 to 250 and even 300 feet. Salt has been found over an area of many hundreds of square miles. There is no natural brine in the boreholes at Hutchinson, though in several parts of the State brine has been discovered. At Hutchinson the Arkansas River is said to flow underneath the flat prairie lands at a short distance from the surface. Anyhow, the salt manufacturers pump up water, found in inexhaustible quantities about 27 feet from the surface, and force it down the boreholes, as in Western New York State and the St. Clair district of Michigan, and by this means obtain one of the purest brines in America. I inspected most of the Hutchinson works on a tropical day. The amount of insect life brought out by the bright sunshine and heat was marvellous, and the shrill whistle of the grasshoppers, which were innumerable, greeted the ear on every side. At night, when the darkness came on, myriads of moths fluttered round the brilliant electric light, and, singeing their wings, fell down into the roadway beneath, where numbers of huge toads sat waiting to devour them for their evening meal. Myriads of fire-flies were to be seen as the train rolled rapidly along during the night. Kansas State is not beautiful, but it is fertile, and will doubtless become the seat of a large population in a short time.

I left Hutchinson in the morning, and reached Kansas city in the afternoon, and found the thermometer standing at 90° in the shade. After staying about an hour, I again left for Chicago. In the early hours I crossed the Missis-

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sippi, being wakened by the coloured porter in the car to see it, as I had no wish to return to England and say that I had crossed the Mississippi twice without seeing it. I again reached Chicago; visited salt stores there, and left for Canada, travelling again all night. After inspecting the various Canadian salt districts, as before mentioned, I returned to Syracuse, in New York State, *via* Niagara Falls.

The Syracuse salt district is a very peculiar one. It is the oldest in the United States; and although brine has been found there on the low grounds near Lake Onondaga, no rock salt had been discovered in any of the wells bored. The brine being only about 18·5 per cent., instead of 25 at least, showed that it must have travelled some distance from the bed of rock salt where it had its origin, and had become weakened by mixture with fresh water on its way. I predicted some years ago that rock salt would some day be discovered in the neighbourhood, and I learned that it had recently been found in a boring at Tully, about 15 miles south. It was intended to utilise the rock salt so found by putting water from a neighbouring lake down the bore hole, and conveying the brine, thus formed, by a line of pipes to Syracuse. The depth of the salt rock from the surface was 1,212 feet. The salt manufacture at Syracuse was very interesting. A large quantity of salt was being made by solar heat, in what are called "covers." These are shallow wooden pans elevated above the ground on props or pillars; each is 16 feet by 18 feet, and from 4 to 6 inches deep. I found over 40,000 of these "covers" on the flat land near Lake Onondaga. The brine wells are from 140 to 300 feet deep; and the brine, or "water" as it is called, is generally found in a bed of gravel. The deeper wells have usually the strongest brine.

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Having visited and inspected almost all the extensive works in the Syracuse district I returned to New York, being unable, for want of time, to visit the salt works in Pennsylvania, Ohio, and West Virginia. It is not my intention to describe the various processes of salt making that I inspected in America. This has been very well done by Mr. T. M. Chatard, of the United States Geological Survey, whose communication has been printed by the United States Government. Mr. Chatard called upon me in Cheshire since my return, but unfortunately I was not at home. He kindly forwarded me his paper, which is very interesting, but only deals with the manufacture of salt.

I think a short statement of the geology of the North American rock salt, gathered from the best and most recent information, and supplemented by enquiries made on the spot, may be useful.

The first rock salt found in North America was in the year 1862, at Petit Anse Island, in Louisiana, not far from New Iberia. It lies at a depth of 16 to 17 feet from the surface. The thickness of the bed has not been proved, though "a shaft has been sunk to a depth of 190 feet. Of this 165 feet are in solid salt, and the bottom has not been reached." (Hay—"Salt and its discovery in Kansas," p. 10.) The American Bureau of Mines published in 1867 an account of this deposit. The section exposed on sinking to the salt is given as follows:—

	ft.	in.
Surface soil, black	1	2
Lighter coloured sandy soil	2	0
Dark sandy soil, containing pottery, &c.	1	0
Coarse sand and gravel	0	6
Sand, with clay	0	6

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	ft.	in.
Reddish sand—gravel and pottery	5	0
Sand	1	6
Blue clay, with vegetable remains, pottery, &c...	2	0
Coarse gravel, without clay	1	6
Clay, gravel, and sand	1	0
Clay, interspersed with drift sand	3	0
Salt	——	
	19	2

The surface of the salt shows decided marks of erosion. It is difficult to tell the exact age of the salt, as the underlying strata have not been reached. It is undoubtedly recent, as compared with many deposits. Hay, in his paper on Kansas salt, describes this Petit Anse salt as of the "Quaternary period;" but the American Bureau of Mines say, "General as well as special analogy points however to its Tertiary age." This rock salt is very pure, and differs very considerably in its form of deposit from our English salt. The peculiarities of its structure lead to the supposition that it was not deposited at the bottom of a salt lake like most salt deposits, or in a lagoon on the sea shore, but probably "from the evaporation of brine springs, originating from beds of rock salt in some older geological formation." I will leave this theory without comment, as I must confess I have always been puzzled with the peculiar structure of this rock salt.

Rock salt was discovered in Arizona some years ago, and a beautiful sample was presented to me. Its structure was like that of our English salt. Beyond knowing that it exists amongst the mountains I have at present no further knowledge. Numerous discoveries of rock salt have been

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made in recent years, but I wish to deal only with those best known and described.

Rock salt and brine have been discovered in West Virginia. The rock salt, of which a sample was given to me, lies about 212 feet from the surface, and has been tested to a thickness of 135 feet. It is similar in appearance to our English rock salts, and, like them, is accompanied by gypsum and marls. The formation lies in the midst of Palæozoic rocks, but is regarded by Professor Lesley as "probably of tertiary age and occupying a very limited basin." I obtained my information as to brine and salt from Mr. Palmer, the owner of the salt works.

Beyond being told that "sources of the brine in the salt wells in the Ohio valley are supposed to be near the base of the carboniferous series," I have no other information of a definite nature.

The position of the Canadian rock salt has been pretty well determined, and Professor Sterry Hunt has dealt with the subject in an excellent paper read before the American Institute of Mining Engineers, at the New York Meeting, February, 1877, entitled "The Goderich Salt Region and Mr. Attrill's exploration." The section shown by the cores extracted may be grouped as follows:—

		ft.	in.
I.	Clay, gravel, and boulders	78	9
II.	Dolomite, with thin limestone layers	278	3
III.	Limestone, with corals, chert, and beds of dolomite	276	0
IV.	Dolomite, with seams of gypsum..	243	0
V.	Variegated marls, with beds of dolomite..	121	0
VI.	Rock salt (1st bed)	30	11
VII.	Dolomite, with marls towards the base ..	32	1
VIII.	Rock salt (2nd bed)	25	4

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		ft.	in.
IX.	Dolomite	6	10
X.	Rock salt (3rd bed)	34	10
XI.	Marls, with dolomite and anhydrite	80	7
XII.	Rock salt (4th bed)	15	5
XIII.	Dolomite and anhydrite	7	0
XIV.	Rock salt (5th bed)	13	6
XV.	Marls (soft) with anhydrite	135	6
XVI.	Rock salt (6th bed)	6	0
XVII.	Marls (soft) with dolomite and anhydrite	132	0
		1517	0

This section may be divided into three main formations, viz.:—

		ft.	in.
1.	The superficial or boulder clay formation	78	9
2.	Dolomite and limestone	797	3
3.	The saliferous	641	0

The saliferous formation "has a position in the geological column in the upper part of the Silurian series. It rests conformably upon the magnesian limestone of the Niagara formation." The borings in Western New York State are very similar to the Canadian; and no doubt the Michigan brine supply, which is described as lying "at the base of the coal measures," is in the same formation.

Section of the Shaft of Retsof Mine, Western New York State.

	Ft.
Encrinal limestone	8
Hamilton shale (Moscow shale)	40
Dark shales	93
Limestone	8
Ludlow shales (Hamilton shale)	216

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	Ft.
Limestone	4
Marcellus shale	39
Corniferous limestone	2
Shale	1
Corniferous limestone	140
Onondaga limestone	1
Hydraulic limestone (water-lime)	13
Sandstone	14
Gypsum	4
Hydraulic limestone	25
Gypsum	47
Magnesian limestone (water-lime)	63
Hydraulic limestone	14
Blue shales	25
Helderberg limestone	10
Blue shales	12
Helderberg limestone	17
Limestone and sandstone	31
Hydraulic limestone	10
Limestone and cement	15
Hydraulic limestone	6
Blue shale	19
Red shale	12
Limestone	41
Red shale	5
Blue shale	12
Limestone	12
Salt shale	51
Rock salt	2
	1012

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The typical boring I find to be as follows:—

1. Clays and gravels.
2. Limestones and dolomites.
3. Salt-bearing marls.

It will be seen that the Western New York, Canadian, and Michigan rock salts were all deposited about the same time, and that the great salt age of the Great Lake District of North America was the Upper Silurian.

The Syracuse brines do not lie on the rock salt, but the various wells "are sunk in a deposit of stratified sand and gravel, which fills up a valley of erosion measuring nearly four miles from north to south by two miles from east to west."

The rock salt of Kansas was only discovered in 1887. It was first struck at Ellsworth at a depth of 730 feet; at Hutchinson, south of the Arkansas river, at a depth of 450 feet; at Kingman, at a depth of 665 feet; at Lyons, at a depth of 785 feet; a little later at Anthony, at a depth of 925 feet; and in 1888 at Nickerson, Great Bend, and Sterling. The thickness of the salt besides the saline shales (or marls) appears to be at

	Feet.
Ellsworth	140
Lyons	250
Hutchinson..	250
Kingman	200
Anthony	75
Great Bend	125
Sterling	198

The Kansas rock salt is "at the base of the Triassic, which is of greater extent than the Triassic deposits of Chester, in England" (Hay).

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I have tried to get sections of some of the borings, but at present have only partially succeeded. Mr. McClain, of Hutchinson, has kindly sent me samples of the salt and also the borings, and, as far as he could, the order of the formation. He says, in a letter just received from him: For some 60 feet down we meet alternate layers of sand and yellow clay; we call this portion the "underflow of the Arkansas river," and we obtain all the water for our brine wells from it. This is succeeded by a conglomerate of sand and clay forming a hard pan, which is immediately succeeded by red clay. Next follows a thick section of blue and red shales, with occasionally grey and black, and small portions of red clay. Following this comes tenacious blue clay, terminating in hard shale, which continues a considerable distance, and is succeeded by the salt. Roughly, the distances would be:—

	Feet.
Sand—yellow clay; hard pan—red clay	85
Blue, red, black, and grey shale, with red clay ..	50
Blue clay and hard shale	238
Salt (bored)..	278
	651

This Kansas formation corresponds very much with the English, and strengthens the theory, which now seems completely demonstrated, that nearly, if not quite, all salt deposits have been formed in salt lakes, as described in my paper on rock salt.

I have endeavoured to give as shortly as possible what is known of the American salt deposits. There is still much to learn. What strikes us most is the enormous extent of the deposits, and their different geologic ages. Salt appears

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to have been deposited in all geologic periods since the first sedimentary rocks, and we have in America deposits extending from the Upper Silurian to late Tertiary, if not to the Quaternary; and certainly, in the "sinks" of the Carson and other rivers between the Rocky Mountains and the Pacific to quite recent times, whilst in the Great Salt Lake and in a Texan lake it is being deposited at the present moment.

NOTE.—*Since the reading of the paper, Mr. Ward has furnished a table of the heights above the sea level of the Rock Salt deposits of New York State, which is added, as an Appendix, on the following page.*

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APPENDIX.

Table showing the position of the Rock Salt in New York State relative to Sea Level—from information given by Dr. F. E. Engelhardt.—Syracuse.

	LOCATION OF WELL.	Elevation of Surface above Sea Level (in feet).	Depth to the Salt below Sea Level (in feet).	Thickness of Salt (in feet).
1.	Leroy—Genessee County..	863	140	Reached Brine, no Rock Salt.
2.	Crystal Salt Co.—Saltvale, Wyoming County	980	395	61
3.	Warsaw Salt Co.—Warsaw, ,, ...	1,090	482	76
4.	Eldridge Salt Co.— ,, ,, ...	1,360	615	54
5.	Kerr Salt Co.—Rock Glen, ,, ...	1,310	705	65
6.	Duncan Salt Co.—Silver Springs, ,, ...	1,407	717	85
7.	Castile Salt Co.—Castile, ,, ...	1,401	969	45
8.	Royal Salt Co.—Mount Morris, Livingstone County ..	602	426	40
9.	Genessee Salt Co.—Piffard, Livingstone County	568	288	71
10.	Retsof Mining Co.— ,, ,, ...	725	285	80
11.	Tully—Onondaga County	901	311	41

The first seven, in Wyoming County, are arranged in order from North to South.

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Mr. DICKINSON said: It is always a treat to hear Mr. Ward discourse on the subject of salt. He has already enriched our Transactions with a valuable paper on the English salt districts, and besides that he has contributed many papers on the salt formations of this country to other Societies, with which you may not all be conversant. The subject is one of which he is thoroughly master. He has now taken us further afield, and has given us descriptions of salt fields which will be—to me at any rate—a subject for mature consideration. The sections (which he did not read) will be of peculiar interest, as showing the actual rocks which lie over the American salt beds, and it will be seen how far they bear out the views he has expressed that those saliferous beds will be found extending from old silurian formations up to some of the newer ones. So far as my own experience goes in this country I have not seen any formation of salt in the old geological strata—they are all in the upper. I have much pleasure in moving a vote of thanks to Mr. Ward for his valuable paper.

The motion was duly seconded, and was carried by acclamation.

Mr. WARD, in briefly acknowledging the compliment, said the preparation of the paper had been a labour of love with him, and he was sorry that the time at his command had not permitted of his entering more fully into particulars. He acknowledged his great indebtedness to everyone he met in America for information upon the subject. The knowledge he gained during his visit, and which he had given in his paper, was as much, he thought, as could be obtained by anyone at present.

Mr. STIRRUP: I would like to ask if Mr. Ward has been able to obtain the height above sea level of the various salt deposits in America.

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Mr. WARD: I have the whole of them in New York State. They are not included in the paper, but I will append a summary giving the heights above sea level of the most important places I visited.

In the course of a brief conversation Mr. DICKINSON drew attention to the large clear crystals of rock-salt exhibited, which Mr. Ward was of opinion had been formed from brine, derived from some older formation.

Mr. DICKINSON said these particular crystals were such as you may see in rock-salt mines in this country, formed near a cavity, but they were not such as occur in the general body of the rock-salt.

Mr. WARD: No; the great bulk of the rock-salt is a mixed up shapeless mass of salt and marl. The peculiar form of the salt crystals is destroyed.

The PRESIDENT: When Mr. Ward's paper is printed it may be convenient to resume the discussion of the subject.

The meeting then adjourned.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XX. SESSION 1889-90.

The ORDINARY MEETING of the Members was held on Tuesday, March 11th, 1890, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, HENRY HALL, Esq., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society :—

Mr. CHARLES S. BENNIS, Surveyor, Golborne, Newton-le-Willows

Mr. JOHN DEAN, Mining Engineer, Wigan Coal and Iron Company, Wigan.

Mr. STIRRUP (Honorary Secretary) stated that he had received a communication from Mrs. Daniel Adamson, acknowledging receipt of the vote of condolence passed at the last meeting on the death of her husband.

The following are the recent additions to the Library, January to March, 1890 :—

Cornwall, Mining Association and Institute of Cornwall: Transactions, Part 2, Vol. II., 1889. *From the Council.*

Edinburgh Royal Physical Society: Proceedings, Session 1888-89, Vol. X., Part 1. *From the Society.*

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Hertfordshire Natural History Society and Field Club: Transactions, Parts 6, 7, Vol. V. *From the Society.*

London Geological Society: Quarterly Journal, No. 181, Vol. XLVI. *From the Society.*

——— Geological Magazine: Nos. 306-309. *Purchased.*

——— Institution of Mechanical Engineers: Proceedings, No. 3, 1889. *From the Institution.*

——— Iron and Steel Institute: Journal, No. 2, 1889. *From the Institute.*

——— Royal Institution of Great Britain: Proceedings, No. 83, Vol. XII., Part 3. *From the Institution.*

——— Royal Society: Proceedings, Parts 284-285, Vol. XLVI., Part Part 286, Vol. XLVII. *From the Society.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Part 4, Vol. XXXVIII. *From the Institute.*

Scotland, Mining Institute of Scotland: Transactions, Parts 7-8, Vol. XI. *From the Council.*

South Wales Institute of Engineers: Proceedings, Part 5, Vol. XVI. *From the Institute.*

Electrical Distribution of Energy in Mines, January, 1890. Pamphlet. By A. T. Snell. *From the Author.*

Outlines of the Geology of Northumberland. By G. A Lebour. 1st Edition. The History of Coal. By Rev. Thos. Wiltshire. Pamphlet. On the Probability of Finding Coal in the South East of England. By W. Taylor. Pamphlet. *Presented by W. Whitaker, F.G.S.*

Liverpool Free Library and Museum: 37th Annual Report, 1889.

Salford Museum, Libraries, and Parks: Annual Report, 1888-9.

Canada, Canadian Institute, Toronto: Proceedings, No. 152, Vol. XXV., Annual Report 1888-9. *From the Institute.*

——— Geological Survey of Canada: Annual Report, 1887-88, Parts 1 and 2, and Maps.

——— Geological and Natural History Survey of Canada: Contributions to the Micro-Palæontology of the Cambro-Silurian Rocks of Canada. By E. O. Ulrich. Part 2. *From A. R. C. Selwyn, F.R.S., Director of the Survey.*

——— Montreal, On New Plants from the Erian and Carboniferous. Pamphlet. By Sir T. W. Dawson. *From the Author.*

——— Ottawa, The Canadian Mining Review: December, 1889, to February, 1890. *From the Editor.*

U.S.A., Cambridge, Harvard College: Annual Report of the Curator of the Museum of Comparative Zoology, 1888-9. Bulletin of the

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Museum of Comparative Zoology, No. 6, Vol. XVI., No. 6, Vol. XVII. *From Alexander Agassiz.*

U.S.A., Philadelphia, Academy of Natural Sciences: Proceedings, May to September, 1889. *From the Academy.*

——— Philadelphia, Journal of Franklin Institute: Nos. 769-771, Vol. CXXIX. *From the Institute.*

——— Philadelphia, Pennsylvania Geological Survey: Annual Report, 1887. South Mountain Atlas, D. C.: Dictionary of Fossils, Vol. I., 1889. *From the Board of Commissioners.*

——— Scranton, Pa., The Colliery Engineer: January and March, 1890. *From the Editor.*

——— Washington, United States Geological Survey: Monograph, No. 13, and Atlas; Geology of the Quicksilver Deposits of the Pacific Slope. By G. F. Becker. No. 14, Fossils, Fishes, and Plants of the Triassic Rocks of New Jersey and the Connecticut Valley. By J. S. Newberry. Bulletin, Nos. 48 to 53. *From the Director of the Survey.*

——— The New Dressing Works of the St. Joseph Lead Company, Missouri. Pamphlet. By Professor Munroe. *From the Author.*

——— The English *versus* the Continental System of Jigging. Pamphlet. By Professor Munroe. *From the Author.*

Sydney, Royal Society of New South Wales: Journal and Proceedings, Part 1, Vol. XXIII., Catalogue of the Library, 1889. *From the Society.*

——— N.S.W., Department of Mines: Annual Report, 1888. *From the Government.*

Victoria, Gold Fields of: Reports of Mining Registrars, September, 1889. *From the Government.*

India, Geological Survey of India: Records: Part 4, Vol. XXII., 1889. *From the Government.*

Berlin, Zeitschrift der Deutschen Geologischen Gesellschaft: Heft 3, Band XLI. *From the Society.*

——— Gesellschaft für Erdkunde: Zeitschrift, Nos. 133-138, 1888, Nos. 139-143, 1889, No. 145, 1890. Verhandlungen, Nos. 1-10, Band XV., Nos. 1-8, Band XVI., No. 10, 1889, Nos. 1-2, Band XVII., 1890. *From the Society.*

Brussels, Catalogue Illustré des Coquilles Fossiles de l'Eocène des Environs de Paris: 4th Part. Par M. Cossmann. *Purchased.*

Kieff, Russia, La Société des Naturalistes: No. 2, Tome X., 1889. *From the Society.*

Kiel, Mittheilungen aus dem Mineralogischen Institut der Universität Kiel: Band I., Heft 2, 1889. *From the Institute.*

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Lausanne, Bulletin de la Société Vaudoise des Sciences Naturelles: No. 100, Vol. XXV. *From the Society.*

Lille, Société Géologique du Nord: Annales XVI., 1888-9. *From the Society.*

Paris, Revue de le Legislation des Mines: November and December, 1889. *Purchased.*

——— Les Cévennes. By E. A. Martel. *Presented by the Author.*

Pisa, Atti della Società Toscana di Scienze Naturali: Memorie, Vol. X., 1889, Processi Verbali, Vols. VI.-VII. *From the Society.*

Rome, Atti della Reale Accademia dei Lincei: Rendiconti, Fasc. 7-13, Vol. V., Fasc. 1-2, Vol. VI. *From the Academy.*

St. Petersburg, Academie Impériale des Sciences: Memoires, Part 17, Tome XXXVI., Parts 1-3, Tome XXXVII. *From the Academy.*

THE DISCOVERY OF COAL MEASURES NEAR DOVER.

By Professor W. Boyd Dawkins, M.A., F.R.S., F.G.S.

The discovery of coal at Shakespeare Cliff, near Dover, is one of those events which mark a new departure in the industrial development of this country. The bare facts of the case have been published in the press, and the full account cannot be written till the completion of the inquiry. As, however, we are all more or less interested in the question of coal, a few details bearing on the discovery and on the general question of the existence of coal in Southern England may fittingly be brought before the Geological Society of Manchester.

The story of the discovery is a striking example of the progress of a scientific idea, passing through various phases, and growing more clearly defined through opposition and failure, until ultimately it has been proved to be true, and likely to lead to industrial changes of national importance.

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The Idea of the Buried Coalfields originated by Godwin-Austen.

The physical identity of the coal-bearing districts of Somerset on the west, and of Northern France and Belgium on the east, was fully recognised by Buckland and Conybeare, as far back as 1826, as well as the fact that the coal-measures lie buried partially under the newer rocks. It was, however, not until 29 years later that the idea of the buried coal-fields was advanced by Godwin-Austen, in a memorable paper (read before the Geological Society of London), "On the possible Extension of the Coal-measures beneath the South-Eastern part of England."* He pointed out that the coal seams are vegetable accumulations, on flat alluvial marshes, close to the water line, and extending over a vast area, and that at the close of the Carboniferous Age the coal-bearing alluvia were thrown into a series of folds, the upper portions of which have, for the most part, been removed by the destructive action of sub-aerial agents, and by the dash of the waves on the shore line, and lastly that most of the present coal-fields are the lower portions of the original curves, which have been preserved by their position from the operation of the above-named destructive forces. Great lines of smashing also and dislocation were developed at the end of the Carboniferous Period. He then proceeded to show that the general direction of the exposed coal-fields in South Wales and in Somersetshire, on the west, and of the Belgian and North French coal-fields on the east, was ruled by a series of folds running east and west, parallel to a great line of disturbance, centered in the ridge, or "axis of Artois"—from the South of Ireland, through South Wales and North Somerset into Westphalia. Throughout this area the exposed coal-fields lie in long,

*Quart. Journ. Geol. Soc., London, 1856, Vol. xii., p. 38.

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narrow, east and west troughs. The series of faulted and folded carboniferous and older rocks, constituting the "Axis of Artois," formed a barrier which gradually sank beneath the sea of the Triassic, Liassic, Oolitic and Cretaceous Ages. Against this the strata of the three first-named ages gradually thin off, while in France and Belgium the coal-measures and the older rocks of the ridge have been repeatedly struck, and are now being worked immediately beneath the cretaceous strata, over very wide areas. The folded coal-fields, moreover, along this line are of the same mineral character, and the pre-carboniferous rocks are the same. This ridge or barrier also, where it is concealed by the newer rocks, is marked by the arch-like fold (anticlinal) of the chalk of Wiltshire, and by the line of the North Downs in Surrey and Kent. Godwin-Austen finally concluded from all these observations, that there are coal-fields beneath the Oolitic and Cretaceous rocks in the South of England, and that they are near enough to the surface along the line of the ridge to be capable of being worked. He mentioned the Thames valley, and the Weald of Kent and Sussex as possible places where they might be discovered.

These strikingly original views gradually made their way, and in the next eleven years became part of the general body of geological theory. They were, however, not accepted by Sir Roderick Murchison, the then head of the Geological Survey, who maintained to the last that there were no valuable coal-fields in Southern England.

The Idea further developed by Prestwich and the Coal Commission.

The next important step in the direction of their verification was that taken by the Coal Commission of 1866-67, by whom Mr. Godwin-Austen and Sir R. Murchison were examined at length, and the results of the inquiry embodied

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in the Report by Mr. Prestwich. In the Report, Mr. Godwin-Austen's views are accepted, and fortified by a vast number of details relating both to the coal-fields of Somersetshire and of France and Belgium. Mr. Prestwich also calls special attention to the physical identity of the coals of these two regions, and to the fact that the Carboniferous and older rocks in both are similarly disturbed. He concludes, further, that the coal-fields which now lie buried beneath the newer rocks are probably equal in value and in extent to those which are exposed in Somerset and South Wales on the west, and in Belgium and France on the east.

The Experimental Boring in the Weald of Sussex.

In 1871 the Coal Commission Report was published, and in the following year the Sub-Wealden Exploration Committee was organised* by Mr. Henry Willett to test the question of the existence of coal in the Wealden area by an experimental boring. The site chosen was Netherfield, near Battle, in Sussex, where the lowest rocks of the Wealden formation form the bottom of the valley. It was resolved to go down to the older Palæozoic strata, which were thought to occur at about 1,000 feet from the surface, or to carry the bore-hole to 2,000 feet if they were not struck before. The work was carried on under considerable difficulties for the next three years, until in 1875 it had to be abandoned at a depth of 1,905 feet, because of the breakage of many hundred feet of lining-pipes, coupled with the loss of the boring-tool at the bottom. The section of the strata passed through is as follows:—

* The Committee consisted of Professors Ramsay and Phillips, Sir John Lubbock, Sir Philip Egerton, and Messrs. Thomas Hawksley, Warington Smyth, Prestwich, Bristow, Etheridge, Boyd Dawkins, Topley, and Willett.

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Netherfield Section.

	Feet.
Purbeck strata	200
Portland strata	57
Kimmeridge Clay*	1073
Corallian rocks*	515
Oxford Clay	60
	1905

This section, although it yielded no information as to the Palæozoic rocks, showed that in this particular district they are more than 1,900 feet beneath the surface, and revealed the great thickness of the Kimmeridge Clay and Corallian rocks. It was sufficiently distant from the ridge of coal-measures and older rocks, against which the Oolitic strata thin away to the north, to allow of an accumulation of Oolitic sediments to a thickness of more than 1,700 feet. In this respect, therefore, it afforded unmistakable evidence that the search for the ridge in question might be carried on with much greater chance of success further to the north, in the direction of the North Downs. The great and increasing thickness of the successive newer rocks of the Wealden formation, which form the surface of the ground between Netherfield and the North Downs, rendered it undesirable to repeat the experiment within the Wealden area proper. Close to Battle, the Secondary strata were of great thickness, and where the whole series of Wealden rocks were present, they were more than 1,000 feet thick.

With this valuable, though negative result, the Sub-wealden Exploration Committee was dissolved, and the next attempt to solve the problem was begun eleven years afterwards, and has recently been crowned with success.

* The precise boundary between these two groups is uncertain. If the Kimmeridge Clay series be taken down to the Coralline Oolite, its thickness will be 1,512 feet.

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For the next eleven years the problem remained where it was left by the results of the Netherfield boring; while in the district of London, evidence was being collected in various sinkings for water, which proved the existence of the Palæozoic ridge of rocks (Silurian and Old Red Sandstones), older than the Carboniferous, at about 1000 feet from the surface. Here, too, the Oolitic strata were not more than 87 feet in thickness, at their thickest point in the well at Richmond. The older rocks, moreover, were inclined at a very high angle, as in the case of the similar rocks underlying the coal-fields of Somerset, and of Northern France and Belgium, and this implied the existence of troughs of coal-measures in the synclinal folds, in neighbouring areas. It was therefore obvious that the line of the North Downs was a desirable region for a second boring in search of the carboniferous rocks.

The Finding of the Coal-Field at Dover.

I come now to the last experiment which has been so fortunately crowned with success. In 1886, I presented a Report to Sir Edward W. Watkin on the general question, and recommended, on both scientific and commercial grounds, that a boring should be made in South-East Kent, in the neighbourhood of Dover, and that the Channel Tunnel Works, now so unfortunately suspended, offered the best site for the trial. It was almost within sight of Calais, where the coal-measures had been proved at a depth of 1,104 feet. It was also not more than six miles to the south of a spot where about four hundredweight of bituminous material was found imbedded in the chalk, in making a tunnel, which, according to Godwin-Austen, had been derived from the coal-measures below. Prestwich also had pointed out, in 1873, in dealing with the question of a tunnel between England and France, that the older rocks were within such easy reach at Dover, that they could be utilised for the making of a sub-marine

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tunnel. Sir Edward Watkin acted with his usual energy, on my report, and the work was begun in 1886, and has been carried on down to the present time, under my advice, and at the expense of the Channel Tunnel Company. The boring operations have been under the direction of Mr. F. Brady, the Chief Engineer of the South-Eastern Railway, to whose ability we owe the completion of the work to its present point, under circumstances of great difficulty.

A shaft has been sunk (A) (*See diagram*) on the west side of the Shakespeare Cliff, close to the shaft of the Channel Tunnel (B) to a depth of 44 feet, and from the bottom of this a bore-hole has been made to a depth of 1,180 feet.

Section at Shakespeare Cliff, Dover.

	Feet.
Lower Grey Chalk, and Chalk-Marl Glauconite Marl Gault Neocomian	500.
Portlandian Kimmeridgean Corallian Oxfordian Callovian Bathonian	660.
Coal-measures, sandstones, and shales and Clays, with one seam of Coal	20.

The coal-measures were struck at a depth of 1,204 feet from the surface, or 1,160 feet from the top of the bore-hole, and a seam of good blazing coal was met with 20 feet lower.

General Conclusions.

The Wealden deposits, which come in just a little to the south of Folkestone, and are over 1,200 feet thick, are conspicuous by their absence in this section. We find none

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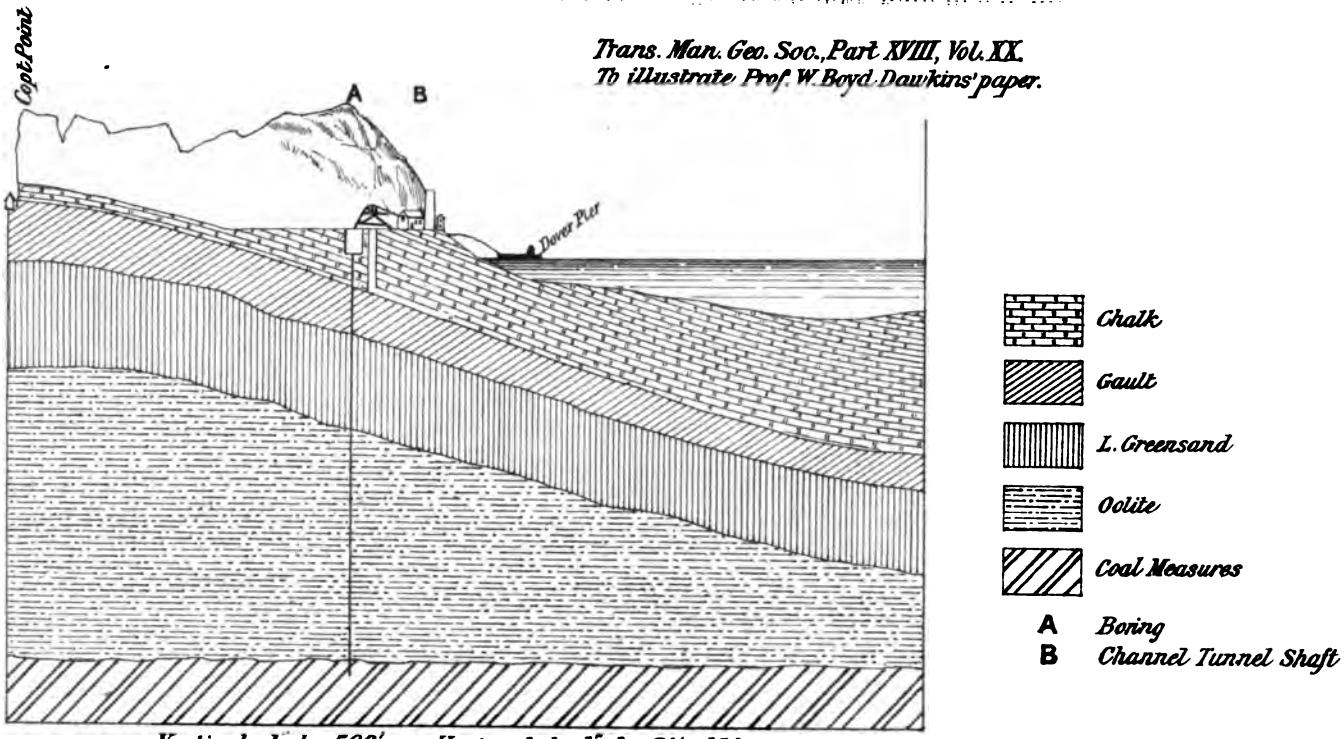
Trans. Man. Geo. Soc., Part XVIII, Vol. XX.
To illustrate Prof. W. Boyd Dawkins' paper.



Vertical, 1" to 500'. Horizontal, 1" to 2½ Miles.

THE BORING AT SHAKESPEARE CLIFF, DOVER.

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of them. We have in place of the Weald clay here the Oolites which underlie the Weald clay. There is another point to be noted. The coal-measures, as I mentioned, have been struck near Calais, and Mr. Godwin-Austen, in his map, has represented the coal-measures, of what may be called the Calais basin, as cut off abruptly by the line of the Channel, and as clearly making for the region of Dover. I have very little doubt in my mind but that we have really struck in this boring at the Shakespeare Cliff the long, narrow belt of coal-measures of exactly the same order as the long, narrow belt, which partly comes to the surface, and partly is concealed underneath the Chalk and Oolites of Belgium and Northern France.

Next comes the question of the value of this new coal-field. In estimating its value, I have the materials ready to hand in that report, to which I have already alluded, of the Coal Commission. Mr. Prestwich, in his account of these rocks, has entered fully into the question of the amount of workable coal which is at present in the Belgian coal-field; and these, either the Belgian coal-measures, or the coal-measures of the North of France, for they are practically the same,—I mean the field extending from Mons and Douai, past Valenciennes—are no less than 9,400 feet in thickness, and they contain 110 seams of coal which are capable of being worked. The united thickness of coal, altogether, amounts to 230 feet. You see then, that, when we look at the Belgian coal-field, we are dealing with a field of enormous commercial value and great economical importance; and when we find that the coal-measures have been struck in the South of England, on the same line as this field, there is every reason to believe that those beds will not be less in value than those of Belgium. That is the evidence, I may say, of the eastern exposed part of these long, narrow, thin troughs of

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coal-measures which are thrown into folds and broken up in a manner which I am quite sure Mr. Greenwell will be able fully to explain from his experience of Somersetshire. In some cases, in one vertical shaft, you may go through the same seam of coal no less than three times. If again we examine the evidence offered by the Somersetshire end of this great line of disturbed coal-measures, we have a thickness (and here again I am appealing to the report of the Coal Commission)—we have a thickness, according to Mr. Prestwich, of 8,400 feet of coal-bearing rocks, containing 55 seams of coal, representing altogether a workable thickness of 98 feet. Thus you see whether you take the Western exposed area of the coal-field, or the Eastern exposed area, you are landed in the conclusion that the coal-measures, which have been struck in the neighbourhood of Dover, are of great commercial importance.

I do not for one moment anticipate what may be the result of our further boring in this spot; but I do say this, that the result already obtained is of enormous scientific and commercial value, not merely because there is a probability of the existence of a valuable coal-field at Dover, but because it gives us definite base line for further explorations. Borings of this kind, carried on under the fostering care of the French Government, have turned two agricultural departments in Northern France into great centres of industry; and it seems to me by no means improbable that in the course of a few years borings will be carried on in Southern England, which will have practically the same result. I look forward, indeed, to the time when the Chalk Downs, which we all delight to wander over, and which are now principally famed for the fine mutton they produce, will be equally famous for the coal they will yield, when the hop gardens of Kent, now remarkable for offering a precarious subsistence to a few farmers and a few labourers, will be great centres

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of business like Liege, Namur, and some other towns across the Channel.

Unfortunately we, in this country, are much worse placed for explorations of this sort than our neighbours in France, and the result of any philanthropic enterprise in which any of my friends may indulge in putting down a bore-hole, would probably mean this:—that he should take the whole risk and bear all the expense, while, if he was successful, the neighbouring landowners would avail themselves of his discoveries without his getting a single penny of profit. That is a very unfortunate state of things; and the problem is of sufficient importance to necessitate some change in mining laws. It seems to me that if this coal producing area of South-Eastern England is to be properly explored we must have some definite arrangement as to who is to do it, and who is to pay for it. This enterprise of ours is to be looked upon mainly as a scientific enterprise, although it may possibly turn out a commercial success. I do not, however, think that very many people would be sufficiently lovers of their country to spend, say £6,000 or £7,000, in putting down a bore-hole on the Chalk Downs, similar to ours, unless they had a possible chance of reaping some pecuniary benefit from it. The question then seems to me to be one worthy the attention of Parliament. I think some sort of arrangement might be devised by which the rights of the explorer might be preserved, while at the same time the rights of the landowner need not necessarily be sacrificed.

In conclusion I would merely say that I shall hope, at a future time, when these explorations are completed, to fill in the blanks which, from the very nature of the case, are necessary in a preliminary communication of this sort. I felt it only right and proper, as a citizen of Manchester, that the first Society to whom this discovery

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should be communicated, should be the Geological Society of Manchester. I do not at all anticipate that this discovery will at all affect the price of coal in Lancashire. I believe that it will develop a new industry down in the South of England. In ancient times the quiet agricultural regions of Sussex and Kent, which are now inhabited by rustics, were even as the Black Country around Wolverhampton is now. There were iron mines, forges, and furnaces, and a vast extent of ash heaps similar to those we may now see in Staffordshire. It would be a curious reversion, if the condition of things, in the days of Elizabeth, should in the days of Queen Victoria, be restored to Kent through the discovery of coal in the neighbourhood of Dover, and if these districts again become a centre of coal production, and probably also of iron production.

Mr. G. C. Greenwell said, before proposing a vote of thanks to Professor Dawkins, he would venture to make one or two remarks. First, he would say with regard to the discovery of coal under the chalk at Dover, that to him it seemed even more wonderful that that discovery had not been made before. So far back as the year 1819, an atlas* was published in which there was a section given of the sinking of a shaft in the French province of Nord, and there could be no doubt that the strata lying beneath the grey chalk corresponded with what the Professor had described. The depth of the shaft in English measurement was 380 yards. Eleven seams of coal were met with of the total thickness of 25 feet 1 inch. There was another observation he would like to make. About the year 1864, when in Belgium, he went down a pit near Mons, inspected the workings, and found them lying exactly in that zig-zag form which had been described, and which, he might add,

* De la Richesse Minérale: Morand, 1819.

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were exactly similar to those made in which the measures were found in Somersetshire—towards the Southern boundary of the measures, where they abut upon the mountain limestone. There were the same zig-zags, and it was perfectly correct what Professor Dawkins had said, for in a mine of which he himself had the management, you could sink through three seams in 100 fathoms down one shaft. When in Belgium he particularly noted the appearance of the coal and its general quality, and was struck with its resemblance to the Southern mines in Somersetshire. The coal was bright, friable and bituminous, corresponding also with that of the Mons seams, which had been mentioned. His impression was that those zig-zag seams corresponded not only in their general character, with the Somerset coal, but it was of the same bituminous character so peculiar to the Southern seams, lying against the Mendips. He was sure all present must have heard with very great interest the paper of Professor Dawkins. They, who were interested in the Lancashire coal trade, had no jealousies, they would be glad if coal were found in the South of England, because, it could not possibly do them any harm. In Kent, if the field of coal should be workable, it might take the place of the wood formerly used in the smelting of iron ore, and revive once more an old industry. He had much pleasure in proposing a vote of thanks to Professor Dawkins.

Mr. Dickinson said, he had pleasure in seconding the vote of thanks to Professor Dawkins. So far as it went the information given was exceedingly interesting and valuable, it only made them wish for more. If Professor Dawkins's surmises were true, the boring at Dover had reached the true coal measures. He supposed the cores would indicate that, and the fossiliferous character of the ground bored through would tend to confirm it, he (Mr. Dickinson) scarcely thought that so cautious a scientific teacher as Mr. Dawkins

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would have led them to hope so much, had he not himself been satisfied that the true coal measures had been reached. During the time of the Coal Commission he was sanguine enough to hope that these events would be realized. The character of the coal-fields beyond the points which Professor Dawkins had laid before them, all indicated that there was a succession of coal-fields—perhaps not continuous but a succession traversing the whole distance from South Wales through the Forest of Dean, Somersetshire, to that little coal-field which lay between Calais and Boulogne, and thence westward of Valenciennes where pits some quarter of a century ago were working down through the chalk, and continuing through the North of France and Belgium to Aix-la-Chapelle and other places in Germany, and even to Warsaw, in Russian Poland. He had always been led to hope that some event of this sort would be realized; but in the absence of full information, and not having seen the cores and complete sections, and from the section given stopping just at the part of the Oolite formation where coal has long ago been met with and worked a little, near Scarborough and Whitby, he would at all events halt before being entirely sanguine and confirmed in this view, that the true coal-field had been struck. Still he thought that the Professor would not have led them to anticipate so much had he not really ground for it; but it would have been most interesting to know somewhat of the dip and the nature of the fossiliferous beds which accompanied the coal measures that have been struck.

Mr. De Rance congratulated the Channel Tunnel Company and Sir Edward Watkin on having had the boldness to carry out the very remarkable boring which Professor Dawkins had described—a boring which he trusted would yield that commercial success which its promoters were entitled to look for. They had been the

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first to utilize the valuable evidence which was contained in the report of the Coal Commission. On the map accompanying that Report, now exhibited by Professor Dawkins, it would be seen that a dotted line was drawn across the South of England where it was thought coal would probably be found, as Mr. Dickinson had pointed out, in isolated places. That line was, he believed, drawn by his (the speaker's) respected former chief, Sir Andrew Ramsay, and enters the coast of Kent at the very point where coal has now been found. The other lines on the map were drawn by Professor Prestwich, and had to do with his sections which were published in the report. Professor Prestwich, it is worthy of note, represented productive coal measures at this locality in his Channel Tunnel paper, and he must say that his first feelings on reading of the remarkable discovery at Dover was that very great thanks were due to Sir Edward Watkin and his colleagues who ordered the boring to be made. Mr. De Rance referred to the results of twelve previous borings in the South of England, that there was a very hopeful prospect of coal being found in workable and commercial quantities along the line which the report of the Coal Commission indicated, ranging north of Salisbury Plain and joining up to the Somersetshire and South Wales coal fields. He hoped that Professor Dawkins' remarks, in which he pointed out how the French Government (and he might have added the German Government also) had increased the mineral wealth of those countries by sinking borings at the public expense, would bear some fruit at this side the channel. He begged to thank—on his own behalf—Professor Dawkins for his valuable paper.

Mr. Greenwell: You don't lose sight of the fact that the minerals in France and Germany belong to the State.

Mr. De Rance: I do not.

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The PRESIDENT said before putting the resolution he would like to say a word in its support. He thought the members of that Society ought to be, and were, proud of the fact that it was one of their fellow members who had made this wonderful discovery of coal in the South East of England. Not only ought they, as a body, to thank Professor Dawkins—it was also a matter for the community. It was, as Mr. Greenwell had already stated, a wonderful thing that this coal had not been discovered before. People in the South of England had been paying 26s. a ton for coal all their lives, whilst they were living on the top of valuable beds, to get at which no effort had been made. If such a state of things had existed anywhere in the northern counties, the coal would have been discovered long ago—and this was proved by the fact that a Lancashire man had to go down to the South of England to discover it for them. He was disposed to ask—Why did scientific men labour all their lives and make discoveries of this kind by which the community benefitted, with no material result to themselves? The thanks of the community they no doubt did receive—and such thanks were sweet—but in this material world one wanted something more than that. There was a Commission now sitting to enquire what right landlords had to the minerals under their estates; and he thought if the claims of scientific men could also be brought under the notice of that Commission something practical might be done for them.

The resolution was carried amidst cheers.

Professor DAWKINS, in responding to the vote of thanks, said: I feel exceedingly gratified by the very kind way in which you have received this fragmentary account—for, from the very nature of the case, I was obliged to put it in a fragmentary fashion before you. I would like to say, with regard to Mr. Dickinson's scepticism—which is of the

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true philosophic kind—that the fact of finding *Calamites*, and of seeing well-defined cores of underclay is to my mind almost better evidence than even the discovery of coal. I have no reason to doubt that we are in the coal-measures, to a depth of upwards of 60 feet. The subject is one of very great importance. I do not profess to have got together, at this short notice, all the information possible; and I, for one, welcome the labours of Mr. Dickinson, Mr. Greenwell, and Mr. De Rance, with the keenest possible pleasure. I feel really that it would be unfair for me to allow the President's remark to pass that I am to be looked upon as the discoverer of this southern coal-field. The discovery is the result of the work of many men who followed the idea which was thrown out by Mr. Godwin-Austen. I am merely one of those workers who has been engaged upon this problem, and it has been my good fortune to aid to carry the enterprise to a success.

This concluded the business of the meeting, Mr. Crankshaw's paper on "Irrigation for the Western States" being postponed.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XX. SESSION 1889-90.

The ORDINARY MEETING of the Members was held on Tuesday, April 15th, 1890, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

Mr. Alderman W. S. BARRETT, Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society :—

THOMAS ROBSON, Orrell, Wigan.

ALFRED E. JOHNSON, Abram Colliery, Wigan.

THOMAS GRUNDY, Wigan Junction Colliery, Abram, near Wigan.

IRRIGATION AND WATER STORAGE IN THE WESTERN STATES OF AMERICA.

BY MR. JOSEPH CRANKSHAW.

In introducing the subject of irrigation and water supply in the United States, I do not think that I can do better than adopt the system used by Major Powell of dividing the country into three regions, named the Humid, Sub-Humid, and Arid, from the number of inches of annual

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rainfall in each. The first or Humid region embraces the whole of the country from the Atlantic coast westward to the line of thirty inches of rainfall, which line, though of an irregular and shifting character, I have taken as following the 95° of longitude west of Greenwich. The whole of the country east of this line has a copious rainfall and water supply, and suffers little from drought. The second or Sub-Humid region embraces the broad belt of territory west of this line and extending to the line of twenty inches of rainfall, beyond which it is considered that agriculture cannot be successful without irrigation. This line, though like the first of a somewhat irregular character, is taken as following the 100th meridian west, and which is called the Arid or Powell meridian. This broad belt, although capable of agriculture, is subject to periodic droughts of disastrous effect, and needs supplementary water supply. The third or Arid region commences at the 100th meridian west, which in passing through the United States cuts into two parts Dakota, Nebraska, Indian Territory, and Texas, and it is to this region that my paper more particularly refers, for the unaided natural rainfall in the vast territory to the west of this meridian is too small for agriculture. This includes an area of one million two hundred thousand square miles of land, or over two-fifths of the United States. The whole of this vast territory is not arid, for a large tract, including Northern California, Western Oregon, and Washington, has an ample rainfall. Neither is the whole of it cultivable even with water supply, for the height and character of the mountain ranges are such as to place them altogether outside the pale of agriculture.

The rainfall of the arid region is not only small but is exceedingly variable, and a district which one year shows a rainfall of forty inches, may show only ten next, and in

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some parts of Arizona is as low as two inches. Not only so, but it generally comes at the wrong time, as most of it comes in the winter, when it cannot be utilised.

The greater portion of the country is also over-drained, as the streams do not flow upon the surface of the land, but have cut their way by erosion deep into the rock, in some cases hundreds of feet, and, as in the case of the larger rivers of Colorado, thousands of feet, so that when the rain does come it at once finds its way into these cañons, which are for a few hours converted into raging torrents, and then dry up again. Travellers have given the gloomiest pictures of this terrible region. Describing the table land as, scorched and barren desert, sparsely covered with grass, and broken up by huge fissures, whose sides were sheer and frightful precipices thousands of feet deep, and at the bottom of whose gloomy recesses the rivers were raging torrents, coursing along with the speed of express trains.

Up to recently the people of the United States have not troubled themselves much about the matter, as they have looked upon it as a country of mines and ranches, but totally unfit for agriculture, and they have had an abundance of fertile land unoccupied in the Mississippi Valley. But most of the good farming land has been appropriated, and when the Oklahoma territory was recently opened there were twice as many settlers ready as there was land for them to occupy. The advice of the eminent American statesman, "Young man, go West," has been accepted, not only by the surplus population of the Eastern States, but by the huge stream of immigrants from Europe. So that the population has increased over eleven millions during the past ten years. Land questions, which could be very well overlooked ten years ago, are now pushing themselves to the front, and in another ten years will become of vital

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importance. Pioneers have been forced farther and farther west, and have found that the barrenness of the much dreaded region was due, not to the natural sterility of the soil, but by an absence or deficiency of water supply, and that when this was rectified the country, in spite of cloudless skies, was equal, and in many cases superior to more eastern states, for producing both grain and fruit.

The irrigation of this vast region is, I think, a question of the greatest interest, not only to America, but to the whole of the civilised world, for it means the reclamation not of a single province even, but of a country nearly ten times the size of the British Islands. Several methods have been adopted to meet the deficiency of rainfall. Some of the farmers in the mountain valleys and on the banks of the smaller streams, have provided a water supply for their farms by roughly constructing a dam of earth or brush across the stream, and conveying the water by means of ditches to their land. The dams generally need reconstructing and the ditches redigging every year, but the labour of this is slight compared with a certainty of raising a crop. Underground waters are also most eagerly and persistently sought for, the Government offering large premiums for Artesian wells producing over a certain number of gallons per hour. In some cases the borings have met with remarkable success, those of the James valley in particular, where there are nearly 100 wells already sunk, no one of which is more than 250 feet deep, and most of them much less, yet all of them show a pressure sufficient to force to an average height of 200 feet a stream of great volume, making the most extraordinary phenomenon of the kind in the world.

But well water is never a perfectly satisfactory supply, and is not always applicable for irrigation purposes,

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although it is the method by which the Dakota and other farmers of the plains must meet the present deficiency of rainfall. This is not, however, the system which is looked upon for the ultimate settlement of the question. The laws of the western states and territories have everywhere recognised and protected the rights of the first or "prior appropriator" of water. Thus, if the first settler on the banks of a stream appropriates, or draws off, half, or the whole of the stream to irrigate his land, he has the right to draw off this half or whole of the stream for ever, to the entire exclusion of any future settler, and this applies not only to the smaller streams but also to the larger rivers. The enterprising Westerner has fully recognised and taken advantage of this right. Instead of waiting for the individual farmer to come and dig his own little ditch and take his little supply for his own farm, large companies have been formed with capital amounting to millions. They have dug enormous canals, many miles in length, some of them 100 feet wide and 10 feet deep, appropriating all the water of the river, and irrigating thousands of farms, to whom settlers have been attracted by advertisement. The *land* belongs to the Government, but is let to the settler at a nominal price, as it is worthless without the water supply. The *water* belongs to the canal company, and it is for this the settler really pays.

These canals follow the contour of the country, running farther and farther away from the river as it falls away. The canals give off lateral branches, which branch off again into ditches, which water every foot of arable land between the canal and the river.

The settler sows his land with grain, or plants it with vines, oranges, or olives, and in five years a hundred square miles of desert are converted into a marvel of fruitfulness, producing under a cloudless sky as no farm in the Eastern

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States can. But this system of irrigation is not looked upon as a possible solution of the question. It is of necessity confined to the rivers that never run dry, and these are already nearly all appropriated. The canals can only follow the contour of the country and water one side, towards the river, the largest of them does not get more than 10 miles away from the main stream.

It is in high altitude reservoirs, storing up the storm and snow waters that the ultimate solution of the problem will be found. These waters are at present wasted, or worse than wasted, as after every rainfall or snow-thaw they convert the rivers into raging torrents, which still further denude the land, and after a few hours or days dry up again into perfect uselessness.

The construction of these reservoirs is of absorbing interest in the Arid region, and a special Senate committee has been making enquiries and gathering evidence upon water supply in the different districts. But private enterprise has not waited for State aid, and several large reservoirs have already been constructed, and have proved the feasibility of the scheme, both from an agricultural and financial view. Four dams have been completed, and a short description of them by a recent writer may be of interest, as each of them represents a different type of structure, and the four together probably all the kinds likely to be built.

"Near Merced, in central California, a large irrigating canal, 75 miles long, has been in process of construction for six years. A few miles from the city the course of the canal lay across a wide valley or depression, around which the canal must either make a wide detour or cross it by an expensive flume. It was finally decided to dam up the lower end of the valley, and convert it into a storage

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reservoir. The dam, of necessity, is one of earth, which was scraped and hauled into place by men and teams. It is nearly a mile long, and is in places 60 feet high. It took five years to build, and as its position is not a favourable one, was very expensive. The lake formed covers 650 acres, and holds when full 5,500,000,000 gallons.

"At Walnut Grove, 40 miles south of Prescott, Arizona, a dam was completed in 1888, which burst with disastrous results a few weeks ago, this also depended upon gravity as the principle of its construction, but was built of stone instead of earth. It lay in the typical position for such structures, closing the narrow outlet of a wide valley. Its situation in the interior and many miles from a railway precluded the use of cement, while the sides of the very cañon it closed furnished an inexhaustible supply of the best granite. The dam was a huge wedge-shaped core of loose rock, thrown in just as it was blasted from the hill sides, and kept in place and shape by wide back and front walls. These walls were hand laid but without cement. With no further protection the water would flow away almost as fast as if no dam were there. This protection was supplied by a double apron or skin of 3-inch planks, lined with tarred felting, calked, and painted with water proof paint, covering the whole water face of the dam, and resembling in many ways the side of a a ship. The dam was 110 feet high, and the lake which formed the largest body of water in Arizona, covered a surface of 750 acres, and impounded 4,000,000,000 gallons.

"The third dam is the one across the Bear Valley, in San Bernardino county, California. It is a carefully constructed but suprisingly thin wall, curving up-stream, and keyed securely into the rocky banks. *Its* principle, that of the arch, is entirely different from that of the two dams

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already described, and the structure would attract attention anywhere for the boldness of its design. It holds back the water, not on account of its weight, but because the arch which it forms transmits the pressure to the sides of the cañon. *It is but 20 feet thick at the base and less than three at the top.* By occupying a position of great natural advantage, this reservoir, with a dam but 60 feet high, covers an area of 7,250 acres, and impounded 4,000,000,000 gallons.

"The aristocrat of the four, however, lies near San Diego, California. It has been built by a company, closely allied to the Atchison Topeka and Santa Fé Railroad Company, across the Sweetwater River, and commands a large tract of country owned by it about National City. It is most carefully constructed of cut rock, laid in Portland cement. It combines the two mechanical principles already mentioned, depending upon its weight for stability, but being built in the form of an arch for additional security. The dam is about 90 feet high, and the lake, now full, covers 725 acres, and holds 6,000,000,000 gallons. The water is conveyed to the land below in iron pipes, instead of the cheaper flumes and ditches. Of these there are already 60 miles in place."

These, briefly described, are four of the principal dams, one of which is already *non est.*

But the enthusiastic Westerner, who is nothing if not large in ideas, does not expect to count the national reservoirs by the unit, but by the dozen or score, and the question is becoming, *Who shall construct them?* The water companies have undoubtedly done good service, especially when we consider the difficulties they have had to overcome in constructing their reservoirs far away from civilisation. They have not only had to construct the dam,

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but the road to it, and have had to convey their machinery, tools, and materials over almost insuperable obstacles. But they are simply money-making syndicates, with no souls to save and no bodies to kick, and have every temptation to reduce their structures to the lowest point of safety in order to reduce expenditure. They are backed up by impatient stockholders, anxious for a return upon their capital, who often know little and care less for the district where their money is invested so long as the percentage is good. What engineer in England would dare to depend upon 3-inch planks and waterproof paint to imprison nearly 18,000,000 tons of water? Does it not seem like tempting Providence to rear a "surprisingly thin wall" sixty feet high, with a mean thickness of only eleven feet to hold back 45,000,000 tons of water? Fortunate it is that the Walnut Grove reservoir was only completed in 1888. Had it remained firm for a few more years until the valley had become thoroughly settled the disaster might have been appalling. What would happen to the "thin wall" of the Bear Valley dam if a slight displacement of strata occurred, or if a thunderbolt struck it, or if a few fanatics with a grievance or a mission and a few pounds of dynamite tackled it some dark night. The fancied security of the people below these dams is only equalled by the confidence of the people who live on the slopes of a volcano, and rebuild their houses over the sites of their ruined homes, while the lava is yet hot, with this difference, a volcano or earthquake may be called the visitation of God, but a weak or defective dam may be due to the wickedness or cupidity of man. The water rents will also become in time a source of grievance, and the people of the Western States have not the respect for vested interest that we have, so that a time will probably come when they will acquire the reservoirs either by compulsory purchase or downright appropriation.

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Everything, to my mind, points to Government irrigation works. The land belongs to the nation. In its present condition it is worthless for agricultural purposes. With water supply, land worth less than a dollar an acre, becomes worth from ten to hundreds of dollars. Many of the works would be self-supporting at once, and if not, the Government is not obliged to have an immediate return, but can look forward for payment to ages. The question with it ought not to be, Will it pay? but, is it for the national good? And the reply to my mind will be an emphatic affirmative.

Public opinion is also asserting itself upon the question of water rights, and several of the legislatures of western states have established the ownership in principle of Government, in all bodies of natural waters.

The Special Senate Committee on Irrigation have also had the assistance of a large staff of surveyors, and hydrographic engineers, who have examined the different districts, and reported upon rainfall, dam and reservoir sites, and the suitability of the land for irrigation. Some of the evidence taken is of an exceedingly interesting character, showing the enormous amount of land still possible to be reclaimed, while some of the schemes proposed are of a magnitude sufficient to overwhelm the average mind. One scheme is to construct a navigable canal from the upper Missouri to the Gulf of Mexico, that will irrigate 50,000,000 acres of land, now largely idle or given to the use of the broad-horned steer at 20 acres per steer. Another is to make Tahoe, Donner, Webber, Honey, and Independence lakes, reservoirs for the Truckee and Carson Valley basins, the latter of which is to be supplied by a tunnel 3½ miles long, and 1,000 feet below the present level of Lake Tahoe. This scheme will reclaim 3,000,000 acres of land,

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and increase its value nearly $10 per acre. The engineers estimate the cost of the scheme at $2,000,000.

A third scheme is the construction of an international dam and reservoir on the Rio Grande, above El Paso, for the purpose of definitely fixing the river bed, and providing for a regular supply of water to both sides of the river.

Much has already been done, but more remains to be done, and many legal issues considered before the question is permanently settled. The Mormons of Utah have 600,000 acres under irrigation, and they have practically solved the question in a very simple manner. The water companies are composed of farmers needing water, and one acre of land represents one share of water.

There are in Montana alone eight irrigation companies, which have at the present time 360 miles of canal, which cost $1,327,000, and irrigate 770,000 acres.

The Boise River basin, in Southern Idaho, is one of the finest irrigation areas in the whole of the arid west. There are in Idaho 12 counties, containing 6,809,900 acres, which are crossed and recrossed by 1,510 miles of canals, and 729 ditches, irrigating 702,200 acres. Arizona has about 150,000 acres in cultivation, irrigated by about 250 miles of ditches, and the Walnut Creek reservoir, Colorado, had in 1886 over 1,000 miles of irrigating canal.

But the land requiring water is infinitely in excess of the land supplied. It is estimated that there are on the plains alone 40,000,000 acres capable of reclamation. In Montana, 35,000,000 acres, or one-third of the state. In the Yellowstone Valley, 9,000,000 acres. In West Washington and Oregon, 12,000,000 acres. In Nevada, the most unpromising field of the whole arid west, the engineers' work has so far progressed as to show the reclaimability of at least 3,000,000 acres. The irrigable possibilities of Cali-

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fornia, are estimated at from 13 to 20,000,000 acres. Arizona has enormous possibilities. While the valley of the Rio Grande must be of intense interest both to S.W. Texas and N.E. Mexico.

I have thus briefly and imperfectly endeavoured to bring before you the three principal methods of irrigation, viz., by well, canal, and reservoir, and in so doing I have been actuated by the feeling that "he who makes two ears of corn or two blades of grass grow where beforetime only one grew," deserves well of his country. I have not attempted to lay before you the economic side of the question, and show you the increased value of the land, and its increased capacity to support population, in round numbers, for hand, eye, and ear, become wearied by the repetition of the same word—Millions!

Millions of acres, millions of dollars, millions of population. But I think that you will agree with me that this is a region to which may be pre-eminently applied the old saying, slightly altered—Where Nature fails Science steps in.

A vote of thanks being unanimously passed to Mr. Crankshaw for his paper,

The CHAIRMAN said: I am sure I have listened with much pleasure to Mr. Crankshaw's paper. Everything that concerns America—a country with which we are closely associated—must be very interesting indeed. Mr. Crankshaw has shown the possibilities of this question of irrigation. One of the most interesting features of his paper was the remarks with regard to the bursting of dams in America, which have been fraught with so much disaster; he has shown us that there is still a great deal to learn, and that our engineering science is not behind in matters of that kind.

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Mr. Stirrup said: The subject which Mr. Crankshaw has introduced is one that is arousing at the present time considerable interest in parts of the United States. This arid region embraces some four-tenths of the whole country, and if only a regular water supply could be secured an enormous extent of land would be brought under profitable cultivation.

The question, therefore, is of great interest—how to make these arid lands in North America productive? They have until recent years been practically valueless to the agriculturist; and, as Mr. Crankshaw has pointed out, Water Companies have seen the advantages which would be conferred on these lands by irrigation, and so from time to time the most suitable lands for the purpose have been taken up in the neighbourhood of the principal streams, which are thus made use of for private speculation, while the companies are not always mindful of the safety of the public in the construction of their engineering works. The difficulty as to water rights is one that will eventually have to be settled by the Government, as no doubt individual settlers often receive arbitrary and unjust treatment by these monopolist Water Companies, which often claim their right to sole use of the streams, which should be free for the irrigation of all the lands through which they pass.

A COLLECTION OF METALLIC ORES FROM DAMARALAND, SOUTH AFRICA.

By Dr. W. G. Black, F.G.S., Ed.

Dr. W. G. Black exhibited a collection of *Metallic Ores* sent to him from Damaraland by a member of the Mining and Exploration Company, which has been exploiting that district for some time, and read the following on the Copper Deposits in Damaraland:—

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Copper Deposits in Damaraland.

(Extract from "The Golden Age," September 26th, 1889.)

In the far N.N.W. corner of Damaraland there exist enormous deposits of copper in the Otavie district which are little known to Europeans, the wildness of the surrounding tribes having hitherto prevented discovery there.

The deposits, however, have been known of and worked by the natives for centuries.

The mines are situated in about the 18th to 19th degree of south latitude, and the 13th to 15th degree of east longitude.

To the north is the Ovampo country, to the east the Bushmen, and to the south the Damaras (Hereros).

The surface lodes of copper and silver, for there is silver there also, extend for a distance of some twelve miles in an E.N.E. direction.

The ores are of various descriptions, copper glance, red oxide, and yellow ores, and the silver is remarkably pure.

These mines are included in the enormous concessions granted to Mr. R. Lewis by Kamaharero, the paramount Chief of Damaraland.

About thirteen months ago Mr. Lewis employed two experienced miners, Mr. J. Freeman and Mr. A. Nicholson, to visit and report on these mines.

About two months ago these gentlemen returned with about two tons of unusually good samples of copper and silver.

They report that the natives have taken away a large amount of the surface ores, and have sunk small shafts in many places.

They also saw the Ovampo natives at work, mining and

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smelting out the copper and silver into bars and ingots, and manufacturing various ornaments from the metals.

They state that these natives understand the inlaying of one metal into another, but from whom they have learned these arts they could not ascertain.

On one of the lodes Mr. Lewis's men sunk a shaft 40 feet deep, in order to prove the depth and width of the lodes.

Excellent results had been obtained.

They also prospected the surrounding country for gold, but were unsuccessful in that respect.

The natives seemed, they said, to have no knowledge of gold, which they examined very curiously when it was shown to them by the miners.

They found the natives very friendly, the country well watered, and abundance of timber.

Another equally good deposit of copper was discovered about 40 miles N.E. of the Otavie mines.

It is probable that a large company will be formed in London for working these mines, the samples of copper having been assayed and given 70 per cent.

The distance from the coast is about 300 miles.

There seem to be no engineering difficulties in the way of a railway, and it is on the great trade road into the interior from Walfisch Bay.

(Signed) Robert H. M. Mann,

Late of Damaraland Mining and Exploration Company.

Dr. Black said: I was induced to bring this communication before the Society for one reason, namely, that the contribution was sent to me from the Cape by a gentleman who is a native of Manchester, the son of a former medical practitioner here, Dr. Mann. Captain Mann, the gentleman to whom I allude, is now the manager of some mining and exploration companies at the Cape; I knew him and his

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father very well, and he consented to send me some specimens over resulting from his explorations. These which are upon the table are some of them. Being myself a former resident of Manchester, I thought it would interest this Society if I exhibited these specimens and made a few remarks concerning the explorations which are taking place in Damaraland.

Dr. Black described the appearance and general character of the specimens as consisting chiefly of *Copper Ores*, which were mostly of two kinds, brown and green, or Cuprite and Malachite, in appreciable richness and abundance. Reports were read of mining exploration in Damaraland (which is now, however, under German Suzerainty), from some newspapers of the Cape Colony, describing the search for gold and other metals. *Cape Argus*, December 18th, 1889: "Report Damaraland Mining and Exploration Co." *The Golden Age*, September 26th, 1889. *The Diggers' News*, September 21st, 1889: "Report Damaraland Mining and Exploration Co., by Captain Mann."

Mr. STIRRUP moved a vote of thanks to Dr. Black for his communication. He added: Dr. Black is an old member of the Society, and the son of an older member, who once resided in Manchester, and he has come down from Edinburgh to give us the benefit of the reports that he has read and to show us these minerals. I have great pleasure in moving this vote of thanks.

The CHAIRMAN, in putting the motion, said it was a matter of congratulation to the Society that a gentleman residing so far away should have remembered his old Manchester friends, and offered them the benefit of his knowledge on so interesting a subject.

The motion was agreed to unanimously.

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ON THE RED AND VARIEGATED MARLS OF THE UPPER DYAS OF MANCHESTER.

Mr. STIRRUP said: In communicating the following notes by Mr. Roeder, and in offering a translation of Dr. Geinitz's paper, published in *Isis in Dresden*, 1889, entitled, "Ueber die rothen und bunten Mergel der oberen Dyas bei Manchester," he had been actuated by the desire that a paper so intimately connected with the geology of Manchester should be available to the members by its appearance in the "Transactions." It is upon "The Red and Variegated Marls of the Upper Dyas of Manchester."

The paper deals mainly with the Permian rocks in the neighbourhood of Manchester and their European counterparts, and with a description of the various animal and vegetable remains characteristic of the beds in question. As Dr. Geinitz, of Dresden, is the greatest European authority on the Permian—or what he prefers to call the Dyas—formation, the specimens, some of which were found recently near Stockport, were sent to him by Mr. Roeder and Mr. Kendal (then assistant lecturer at Owens College). They have thus been authoritatively named, and the particulars are given in this short paper.

SOME NEWLY DISCOVERED SPECIES IN THE UPPER PERMIAN DEPOSITS OF MANCHESTER.

By Mr. CHARLES ROEDER.

(Communicated by Mr. MARK STIRRUP, F.G.S.)

Professor Dr. H. B. Geinitz, of Dresden, one of our greatest authorities on the Permian formation or Dyas, who in company and under the guidance of the late Mr. E. W. Binney, visited, years ago, the outcrop of the Manchester

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Upper Permian strata, permitted me to submit to him a series of fossils derived from these local beds which I have collected at various periods, to which were also added specimens from Stockport found by Messrs. P. F. Kendal and Grey. These specimens were subjected to a special examination by the Professor and so interested did he become in their study that he was induced to write a short but very valuable paper on them, entitled: "*Uber die rothen and bunten Mergel der oberen Dyas bei Manchester*," *viz.*, "*On the Red and Variegated Marls of the Upper Dyas at Manchester.*" The paper is published in the July number, 1889, of the "Isis" and contains a minute review of the leading fossils therein found. Such a work is a welcome addition to our local geology, it also gives us the corresponding nomenclature of the German and English authorities and, therefore, must prove invaluable to the student. It is not my intention to enter into the discussion of the paper itself as there is little to add so far as Manchester itself is concerned. The specimens I sent have been returned, through Mr. Kendal, to the Owens College Museum, where, no doubt, they may be found and seen by the members. Since Binney's and Captain Brown's time Prof. Geinitz has been able to add the following specimens as quite new to Manchester:—

1. *Aucella Hausmanni* Goldfuss
2. *Avicula Kazanensis* de Verneuil

} Found by me in a fossiliferous Breccia.

3. *Dentalium Speyeri* Geinitz, from the Red Marls at Ancoats.

4. *Vermilia obscura* King, both from Mauldeth Road and Stockport.

5. *Filograna Permiana*, King, needle-shaped tubes, from Strangeways, Ardwick, and Belle Vue gardens, and also at Stockport.

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The position of this species is still doubtful, and Prof. Geinitz suggests that it may belong to the Pteropoda. It also resembles the attachment tubes of Strophalosia, but I am inclined to differ, as not even a trace of a Strophalosia has been found in the strata of Manchester, although carefully looked for during many years by me. Of plants he names:

6. *Ullmannia selaginoides*, Bgt. of which I have collected specimens from Mauldeth Road.

7. *Voltzia Liebeana* Geinitz
8. *Guilielmites Permianus* Geinitz
9. *Spongillopsis dyadica* ,,

} The latter three derived from Stockport by Messrs. Kendal and Gray.

The specimens previously known to Manchester *amount to 10 only*, so that with those recently added *our list has almost doubled*, a fact which may encourage geologists to search more minutely with a view to augment the number of remains relating to the Manchester Upper Permians.

The thanks of the meeting were given to Mr. Stirrup for his communications.

ON THE RED AND VARIEGATED MARLS OF THE UPPER DYAS, NEAR MANCHESTER.

By Dr. H. B. Geinitz, of Dresden.

Translated by Mr. Mark Stirrup, F.G.S., from Ges. Isis in Dresden, 1889.—Part 3.

Through the friendly mediation of Mr. C. Roeder, of Fallowfield, near Manchester, a large number of fossils, from the Red and Variegated Marls in the neighbourhood of Manchester, has been sent to me for examination from

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Mr. P. F. Kendall, of Owens College, to which Mr. Roeder and Mr. Grey, of Stockport, have added a thankworthy supplement for the Mineralogical Museum of Dresden.

The whole series of rock specimens lying before me consists principally of red shaly marls, of darker and lighter colour, often also greenish, with alternations of red, often much iron-impregnated sandstone and conglomerate, as also thin layers and nodules of light gray, also partially reddish, dolomitic limestone.

The varied order of succession of the numerous beds in these Red and Variegated Marls has been fully described in the various writings (illustrated by numerous sections) of E. W. Binney, a distinguished and indefatigable observer.*

According to E. W. Binney (l. c. 1862, p. 45) the Permian and Triassic Strata near Manchester occur in the following descending order :—

1. Strata of red and variegated Marls, containing thin layers of Limestone and Gypsum, and beds of Sandstone; they contain fossil mollusca of the species *Schizodus, Bukevellia, Pleurophorus, Turbo, Rissoa, &c.;* about 300 feet thick.

2. Conglomeratic brown Sandstone, about 50 feet thick.

3. Soft red or variegated Sandstone, about 500 feet thick (Collyhurst).

4. Conglomeratic Sandstone (Astley) with pebbles of

* 1841. Transactions of the Manchester Geological Society, Vol. 1, p. 35-62.

1855. Memoirs of the Literary and Philosophical Society of Manchester (Session 1854-55), on the Permian beds of the North West of England.

1857. Additional Observations, Ib.

1862. Additional Observations on the Permian beds of South Lancashire. (Ib., Session 1861-62.)—Further Observations on the Carboniferous, Permian and Triassic strata of Cumberland and Dumfries. (Ib., Sess. 1861-62.)

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white quartz, and shingle with impressions of coal plants, about 60 feet thick.

Whilst the upper limit of these strata, after the superposition of the variegated Sandstone of the Trias, does not here appear very distinctly marked, there is to be observed in many localities an unconformable stratification of these deposits comprised as Permian, at the lower limit, where it overlies the Middle and Lower Coal Measures, whose thickness is estimated at 5,000 feet.

The fossils which characterise the Dyas or Permian group are only found in the Red or Variegated Marls, and their limestone intercalations, of which latter, E. W. Binney in a section at Astley, in a space of 230½ feet, has distinguished 55 beds. Among the fossils in these variegated Marls the most important and characteristic of the Upper Zechstein, is *Schizodus Schlotheimi.*

For the prevention of the further confusion of this species with other species of *Schizodus* the following explanations may be useful:—

1. *Schizodus Schlotheimi* Gein.

1816/17. *Tellina?* Schlotheim, Denkschr. d. K. Ak. d. Wiss. zu München, p. 31, Taf. 6, Fig. 4, 5.

1820. *Tellinites dubius**) Schlotheim, Petrefactenkunde, p. 189.

1841. *Cucullaea Schlotheimi* Gein. im N. Jahrb. f. Min., p. 638, Taf. 11, Fig. 6.

1848. *Schizodus Schlotheimi* Gein. Versteinerungen des Zechsteingebirges, p. 8. z. Th., Taf. 3, Fig. 23—39. (The Fig. 31, and 32 Mantle impressions figured, are wrong. Fig 33 belongs to *Schiz. rotundatus* Brown sp.)

1850. *Schizodus Schlotheimi* King, a Monograph of the Permian Fossils, p. 191, Pl. 15, Fig. 31 (not Fig. 32).

1856. *Schiz. Schlotheimi* King in Journ. of the Geol. Soc. of Dublin, Vol. VII., P. 2, b. 10, Pl. 1, Fig. 6 (vorzügliche Abbildung!).

* Die Art und Weise, wie Schlotheim das Wort "*dubius*" hier gebraucht und verstanden hat, rechtfertigt den bei näherer Kenntniss der Art dafür eingeführten Species-Namen "*Schlotheimi.*"

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The transverse-oval shell, prolonged backwards and falling away from a blunt edge is above all distinguished by its bellied arched boss, which, with increased age, swells up more and more and becomes more prominent. The anterior margin is uniformly arched and falls away gradually to the less arched ventral margin. The posterior margin is cut off obliquely. Shell thin and only covered with faint growth bands.

Specimens of the normal condition and of various sizes, up to about 4 c.m. long, are found along with many younger specimens shortened in the length, as is very common in the Upper Zechstein, the so-called Plattendolomit of Germany. The Axinus species, as they have been described by Captain Brown in the Transactions of the Manchester Geological Society, Vol. 1., 1841, p. 65, Pl. 6, from Newtown, near Manchester, may be looked upon as such young specimens of *Schizodus Schlotheimi*.

The same approximate more to *Schizodus Schlotheimi* than *Schizodus obscurus* Sow. sp., with which Professor King has associated that unnamed figure of Brown, Fig. 18 of Pl. 6, as also *Axinus parvus* Brown, Pl. 6, Fig. 30, and *Axinus undatus* Brown, Fig. 31, with a (?).

Also *Axinus pucillus* Brown, Pl. 6, Fig. 32, and *Lucina minima* Brown, Pl. 6, Fig. 33, may be but young states of *Schizodus Schlotheimi*.

Prof. King has made the latter, together with *Axinus rotundatus* Brown, Pl. 6, Fig. 29, a special species:

2. *Schizodus rotundatus* Brown sp.

1850. King, Mon. Perm. Foss., p. 190, Pl. 15, Fig. 30, includes *Schizodus Schlotheimi* Var. Geinitz, Verst. des Zechsteingebirges, Taf. 3, Fig. 33.

Characteristic of *Sch. rotundatus* would be a less broad, but somewhat higher and more roundly developed shell,

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and the umbone approaching more the middle of the shell's length.

The near affinity of both species comes out best on a comparison between the delineations of *Sch. rotundatus* in King, Mon. Perm. Foss., Pl. 15, Fig. 30, from the Red Marls of Newtown, near Manchester; and that of *Sch. Schlotheimi* in King, Mon. Perm. Foss., Pl. 15, Fig. 31, from Marsden; whilst King's representation Fig. 32 belongs rather to *Sch. obscurus* than to *Sch. Schlotheimi*.

Larger specimens, which may be called *Schizodus rotundatus*, are also described by Professor Waagen in the Palæontologica Indica, Salt Range Fossils, p. 233, Pl. 19, Fig. 11-12, from the Productus Limestone of India, and which have been distinguished by this name.

3. *Schizodus obscurus* Sow. sp.

1821. *Axinus obscurus* Sowerby, Mineral Conchology, Tab. 314.

1850. *Schizodus obscurus* King, Mon. Perm. Foss., p. 189, Pl. 15, Fig. 22, 23.

1852/54. F. Römer in Bronn's Lethaea geogn., 3 Aufl. II, p. 413 ex p., Taf. III', Fig. 8 a, b.

1861. Geinitz, Dyas, p. 65, Taf. 13, Fig. 13-21.

It is the most elegant among the *Schizodus* group of the Zechstein. The shell possesses a more slender umbone than *Sch. Schlotheimi*, and diminishes yet more towards the obliquely cut off posterior margin than in that species, which is also already the case in its young stage. (Dyas, Taf. 13, Fig. 13.) A bending in of the shell at the ventral edge near the posterior margin becomes still more prominent in this, than in the other species.

The shell substance is far stronger than in *Sch. Schlotheimi*, which is visible even where both species occur side by side, as in the Upper Zechstein of Niederrodenbach and Rückingen in the Wetterau.

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Therefore the muscular and pallial impressions also appear far clearer on their *casts* than on those of *Schiz. Schlotheimi.*

It is highly probable that the unnamed drawing Pl. 6, Fig. 18, of Captain Brown from the Variegated Marls of Newtown, near Manchester; also Professor King's, Mon. Perm. Foss., Pl. 15, Fig. 32—may be classed with *Schiz. obscurus.*

This species is characteristic in the Zechstein at Stadtberge (Marsburg), in the government district Arnsberg in Westphalia.

Among the described species of Waagen, from India, this would be represented by *Schiz. pinguis* Waagen, p. 236, Pl. 19, Fig. 7-10, which species, however, approaches, perhaps, yet more to *Schiz. Schlotheimi.*

Schizodus truncatus King, 1844.

1850. King, Mon. Perm. Foss., p. 193, Pl. 15, Fig. 25-29.

1853. v. Schauroth, Sitzungsber, d. K. Akad. d. Wiss. zu Wien, XI, Fig. 15.

1861. Geinitz, Dyas, p. 63, Taf. 13, Fig. 1-6.

Of oblique-oval-trapezoidal contour, the shell is slightly broader than high, its umbone less projecting than in other species, lies somewhat before the middle of the length (or breadth).

Between it and the very slightly arched ventral margin, the shell is more even and less ventricosely curved than in *Sch. Schlotheimi.* The shell also slopes more uniformly towards the rounded anterior margin, while the posterior sloping surface runs off from one edge towards the obliquely cut-off posterior margin. The dorsal and ventral margins of the shell run almost parallel.

The occurrence of this species is limited to the lower and middle Zechstein and is found especially in the Shell Limestone, near Sunderland; whereas it appears to be absent in

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the Upper Zechstein, to which the Variegated Marls in the neighbourhood of Manchester belong.

Among the Indian species, according to our conception, *Schizodus dubiiformis* Waagen, l. c. p. 238, Pl. 19, Fig. 15, 16, would rather border upon *Sch. truncatus* than *Sch. Schlotheimi* (= *Tellinites dubius* Schloth.) unless we unite it with *Sch. rotundatus.*

Schizodus Rossicus de Verneuil.

1845. Murchison, de Verneuil et de Keyserling, Géologie de la Russie d'Europe etc., Vol. II., p. 309, Pl. 19, Fig. 7 a, b, 8.

1866. Geinitz, Carbonformation und Dyas in Nebraska. (Abh. d. K. Leop. Carol. D. Ak.) p. 18, Taf. 1, Fig. 28, 29.

Though the smaller of the specimens figured by De Verneuil shows an approach to young conditions of *Schiz. Schlotheimi* and *Schiz. truncatus,* to which they have been added by King and in Geinitz, Dyas, p. 63, still the constancy of this species becomes more prominent in the more developed specimens, as is also the case with the specimens near Nebraska city.

Their shell is less broad and the umbone situated almost in the middle of the length is somewhat thicker and more arched than in *Schiz. truncatus.*

How excellent De Verneuil's drawing, Fig. 7, is, notwithstanding its diminutive size, is seen from a specimen of Petscherskoje on the banks of the Volga, Govt. Simbirsk. The same is 20 m.m. long (or broad) and 15 m.m. high, and answers very accurately to Fig. 7, which Verneuil puts forward as especially characteristic.

From the Zechstein strata of Russia various species are sometimes designated as *Sch. Rossicus.*

A somewhat flatter arched *Schizodus* from a dolomitic rock of Schungur at the Scheschma, tributary of the Kama, Gouv. Samara, which is 14 m.m. long and 10 m.m.

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high, belongs to *Sch. truncatus*; through Prof. Grewingk I received specimens from the Upper Dolomitic Zechstein of Niegranden at the Windau*, which testify to the typical occurrence of *Schizodus Schlotheimi*. Different Russian and American Schizodus are preserved in the K. Mineralogical Museum at Dresden. *Schizodus Rossicus* is not known from the beds near Manchester.

4. *Edmondia elongata* Howse.

1848. Howse, Trans. Tyneside Nat. Field Club, I., 3, p. 243. *Edmondia Murchisoniana* King, Catalogue of the Org. Rem. of the Permian Rocks, p. 10.
1850. Ib. King, Mon. Perm. Foss., p. 165, Taf. 14, Fig. 14-17.
1861-62. *E. elongata* Gein., Dyas I., p. 69, Taf. XII., Fig. 26-28.

The occurrence of this species in the Variegated Marls is still questionable, yet probable.

5. *Pleurophorus costatus* Brown sp.

1841. *Arca costata* Brown, Trans. Manchester Geol. Soc. I., p. 66, Pl. 6, Fig. 34, 35.
1846. *Cypricardia Murchisoni* Geinitz, Grundr. d. Versteinerungskunde, p. 434, Taf. 19, Fig. 2.
1850. *Pleurophorus costatus* King, Mon. Perm. Foss., p. 181, Pl. 15, Fig. 13-19.
1856. *Clidophorus costatus* v. Schauroth, Zeitschr. d. Deutsch. geol. Ges. VIII., p. 229, Taf. 11, Fig. 2.
1861. *Pleuroph. costatus* Gein., Dyas I., p. 71, Taf. 12, Fig. 32-35.

Not rare. This species, moreover, occurs from the lowest layers of the Zechstein up to the youngest.

6. *Clidophorus Pallasi* de Vern. sp.

1845. *Mytilus Pallasi* Murchison, de Verneuil et de Keyserling, Géol. de la Russie, II., p. 316, Pl. 19, Fig. 16.
1850. *Cardiomorpha modioliformis* King, Mon. Perm. Foss., p. 180, Pl. 14, Fig. 18-23.
1856. *Clid. Pallasi* v. Schauroth in Zeitschr. d. Deutsch. geol. Ges. VIII., p. 229, Taf. 11, Fig. 3.
1861. Ib. Gein., Dyas I., p. 70, Taf. 12, Fig. 29-31.

* Grewingk in Zeitschr. d. Deutsch. geol. Ges. 1857, p. 163.

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The English forms of this species appear mostly somewhat shorter than the Russian, yet transitions take place between both. This, in Russia, very diffused species is there not confined only to Permian Limestone of the upper horizon, which by degrees passes over into the Variegated Marls, but appears also in the deeper (older) beds.* In Germany *Clidophorus Pallasi* is found in great quantities in the Rauchwacke of the Middle Zechstein, especially near Pösneck in Thuringia.

7. *Aucella Hausmanni* Goldfuss sp.

1829. *Modiola acuminata* und *Mytilus squamosus* Sedgwick, in Trans. Geol. Soc. London, 2 d. series, Vol. III., p. 119 u. 120.

1834-40. *Mytilus Hausmanni* Goldfuss, Petr. Germ., II., p. 168, Taf. 138, Fig. 4. (Die älteste Abbildung!)

1850. *Mytilus squamosus* u. *M. septifer* King, Mon. Perm. Foss., p. 159, 160, Pl. 14, Fig. 1-13.

1856. *Myt. squamosus* King, Journ. Geol. Soc. Dublin, VII., Pl. 1, Fig. 3.

1861. *Aucella Hausmanni* Gein., Dyas I., p. 72, Taf. 14, Fig. 8-16.

One good specimen of this occurs at least, collected by Mr. C. Roeder in a shell-breecia of the Variegated Marls near Manchester. In Germany it always accompanies *Schiz. Schlotheimi*. Here and there it already appears also in the lower beds of the Zechsteins.

8. *Avicula Kazanensis* de Vern.

1845. Murch., de Vern. et de Keyserling, Géol. de la Russie, II., p. 320, Pl. 20, Fig. 14.

1861. *Avicula Kasanensis* Gein., Dyas I., p. 75.

This rare species was also discovered by Mr. Roeder in the Variegated Marls near Manchester.

* Of Amalizky, über das Alter der Stufe der bunten Mergel im Bassin der Wolga und Oka. St. Petersburg, 1886.

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9. *Gervillia (Bakevellia) antiqua* Mün. sp.

1834-40. *Avicula antiqua* Mün., Goldfuss, Petr. Germ., II., p. 126, Taf. 116, Fig. 7.

1841. *Avicula inflata*, *A. Binneyi* a. *A. discors* Brown, Trans. Manchester Geol. Soc. I., p. 65, Pl. 6, Fig. 27-30.

1845. *Av. antiqua* Murch., de Verneuil et de Keyserling, Géol. de la Russie, II., p. 319, Pl. 20, Fig. 13 a.

1850. *Bakevellia antiqua* King, Mon. Perm. Foss., p. 168, Pl. 14, Fig. 28-34.

1853. Ib. v. Schauroth, Sitzb. d. Wiener Ak. d. Wiss. XI., Fig. 2.

1856. Ib. King, Journ. Geol. Soc. Dublin, Vol. VII., P. 2, p. 8, Pl. 1, Fig. 4.

1864. *Gervillia antiqua* Gein., Dyas, p. 78, Taf. 14, Fig. 17-20.

1867. *Bakev. antiqua* Baily, Figures of Char. British Fossils, Pl. 42, Fig. 7.

Gervillia or *Bakevellia antiqua* is the most abundantly occurring species in the Variegated Marls near Manchester, yet it ranges through all the beds of Zechstein from the oldest upwards.

Besides the before mentioned Conchifera of the Manchester collections, we meet with, among the Gasteropoda, the small species described by Brown :

10. *Natica minima* Brown.

1841. Trans. Manchester Geol. Soc., I., p. 64, Pl. 6, Fig. 22-24.

1850. King, Mon. Perm. Foss., p. 212, Pl. 16, Fig. 29.

1861. Geinitz, Dyas I., p. 50, Taf. II., Fig. 20-22.

The appearance of the species in the white Zechstein-dolomite of Mühlberg, near Sachswerfen, on the southern slope of the Hartz, and in the Upper Zechstein beds of Wetterau nearly corresponds to its occurrence in the red dolomitic Marls of Newtown, near Manchester.

11. *Turbo helicinus* Schloth. sp.

1820. *Trochilites helicinus* Schlotheim, Petrefactenkunde, p. 161.

1841. *Turbo Mancunensis* u. *T. minutus* Brown, Trans. Geol. Soc. Manchester, I., p. 63, Pl. 6, Fig. 1-5.

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1841-44. *Turbo Meyeri* Mün, Goldfuss, Petr. Germ., III., p. 92, Taf. 192, Fig. 3.

1850. *Turbo helicinus* u. *Turbo Mancunensis* King, Mon. Perm. Foss., p. 204, 205, Pl. 16, Fig. 19-22.

1856. King, in Journ. Geol. Soc. Dublin, Vol. VII., P. 2, p. 11, Pl. 1, Fig. 7.

1861. *Turbo helicinus* Gein., Dyas I., p. 49, Taf. 12, Fig. 3-4.

Rare in the deepest (oldest) Zechstein, more abundant in the Middle; it occurs still in the Upper, as in the Red Marls of Manchester.

12. *Turbo obtusus* or *Rissoa obtusa* Brown.

1841. *R. obtusa* und *R. minutissima* Brown, Trans. Manchester Geol. Soc., I, p. 64, Pl. 6, Fig. 19-21 und Fig. 12-14.

1861. *Turbo obtusus* Gein., Dyas I., p. 48, Taf. 11, Fig. 16, 17.

From the Lower Zechstein upwards to the Middle Zechstein, and in the Red Marls of Manchester.

13. *Rissoa Gibsoni* Brown.

1841. *Rissoa Gibsoni* Brown, Trans. Geol. Soc. Manchester, I., p. 64, Pl. 6, Fig. 15-17.

1850. Ib. King, Mon. Perm. Foss., p. 209, Pl. 16, Fig. 17.

1856. Ib. King, Journ. Geol. Soc. Dublin, VII., P. 2, p. 11, Pl. 1, Fig. 11.

1856. *Rissoa Gibsoni* v. Schauroth, Zeitschr. d. D. geol. Ges., VII., p. 240, Taf. 11, Fig. 9.

1861. Ib. Gein., Dyas I., p. 48.

Species not surely defined, somewhat shorter and longer specimens also occur along with normal forms, the former of which Kirkby in Quart. Journ. Geol. Soc., Vol. XVII., Pl. 7, Fig. 1-6, has united with *Rissoa Leighi* Brown, Trans. Manchester Geol. Soc. I., p. 64, Pl. 6., Fig. 9-11, whilst he designates the longer form p. 300, Pl. 7, Fig. 9-10, as *Turritella* or *Turbonilla Altenburgensis* Gein.

Both are closely allied, as one also sees from a comparison of the good representations of King, Journ. of the Geol.

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Soc. of Dublin, Vol. VII., Pl. 1, Fig. 10 (*Rissoa ? Altenburgensis*) and Fig. 11 (*Rissoa ? Gibsoni.*)

Turbonilla (*Chemnitzia*) *Altenburgensis* Gein. Dyas 1, p. 48, Taf. 11, Fig. 14-15, is a characteristic fossil for the Upper Zechstein, where it almost always accompanies *Schizodus Schlotheimi.*

14. *Dentalium Speyeri* Gein.

1852. Geinitz im Jahresbericht der Wetterauer Ges., von 1850/51, p. 198.

1853. *Dent. Sorbii* v. Schauroth in Sitzb. d. K. K. Ak. d. Wiss. zu Wien, XI., p. 37, Fig. 20. (Not *D. Sorbii* King.)

1861. *D. Speyeri* Gein., Dyas, p. 57, Taf. 12, Fig. 11-13.

From the deepest beds of the Zechstein formation up to the youngest, yet everywhere rare.

One specimen lies before me with *Bakevellia antiqua* from the Red Shales of Manchester—

Here and there on the shells of *Schizodus* or *Bakevellia* appear traces of *Annulata*, as

15. *Vermilia obscura* King, 1850, Mon. Perm. Foss., p. 56, Pl. 6, Fig. 14, with which also corresponds *Serpula pusilla* Var. a. Geinitz, ex parte Dyas, p. 39, Taf. 12, Fig. 1.

16. *Filograna Permiana* King.

1850. Mon. Perm. Foss., p. 56.—Geinitz, Dyas, p. 41.

It is very questionable whether a series of needle-shaped, almost smooth tubes, lying around in great numbers in reddish clayey layers of limestone from the neighbourhood of Manchester, belongs to this. They appear straight or somewhat bent and round-stemmed, often Dentalium-like, tapering gradually to a point, which is often broken off, and is closed as in a *Serpula.*

Their length scarcely exceeds 6 m.m. by 0·2 to 0·4 m.m. thick.

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These bodies often much resemble the tubular spines of a *Strophalosia*, like those drawn by King (Mon. Perm. Foss., Pl. 12, Fig. 33), though their isolated position gives no support to this view.

By such a derivation, they would be the first and only traces of a Brachiopod in the strata of the Upper Zechstein.

Perhaps these bodies occupy a more appropriate position near the PTEROPODA by the side of the palæozoic TENTACULITES. It deserves to be specially mentioned that *Filograna Permiana* King, also occurs in the Plattendolomite, North-East of Gumpelstadt near Salzungen in Thüringia, by the side of *Schizodus Schlotheimi* and *Aucella Hausmanni*.

17 and 18. Plant-remains occur in the Variegated Marls of Manchester, but very sparsely disseminated. (No. 19) of the Manchester Museum Collection reminds one of the branches of *Ullmannia selaginoides* Bgt. sp. (Gein., Dyas, Taf. 31, Fig. 17-20, and Nachtr. z Dyas I., 1880, Taf. 4, Fig. 1-3) and of *Voltzia Liebeana* Gein. (1880, Nachtr. z, Dyas I., p. 26, Taf. 5, Fig. 1, 2.

As No. 23 of the Museum Collection in Manchester shows traces of fruit cones of *Voltzia Liebeana*, resembling the figures in Gein. Nachtr. z, Dyas 1, Taf. 5, Figs. 5-19, so the occurrence of that leaf covered branch on No. 19 is probably related more to *Voltzia* than to *Ullmannia*. To this may be added the resemblance of the remains upon No 22 of the Museum Collection to the male-flower state of *Voltzia Liebeana* Gein. Nachtr. z, Dyas 1, Taf. 5, Fig. 26. The latter possesses, moreover, but a distant resemblance to the problematical *Chondrus? Binneyi* King, Mon. Perm. Foss., Taf. 1, Fig. 1.

If one wishes to class the before-mentioned plant-remains with *Voltzia*, we need not hesitate to class therewith a cast

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of a stem fragment before us, although a microscopic structure thereon offers no determination.

It may be also mentioned that *Voltzia Liebeana* appears not only in the Kupfer-Schiefer of the Lower Zechstein, but it also has certainly been met with in the Platten-dolomite of the Upper Zechstein in Saxony.

19. A large specimen, (15 m.m. in size) of *Guilielmites permianus* Gein., as it occurs under No. 28 of the Museum Collection, may with certainty be classed as such, as it exactly agrees with our typical specimens from the Rothliegende of Grüna near Chemnitz (Gein., Leitpflanzen des Rothliegenden in Sachsen, 1858, p. 19, Taf. 2, Fig. 6-9).

One recognises the organic nature of these bodies and their connection with the Palms by their unmistakable resemblance to the fruits of the living *Guilielma speciosa* Martius, of which specimens are figured in the previously quoted references; far less characteristic are those forms mentioned as species of *Guilielmites* in Dyas II., 1862, Taf. 25, Fig. 7-9.

Young specimens of *Guilielmites*, only about 2 m.m. in size, which lie scattered on No. 15, can be looked upon as the young condition of *G. Permianus*, or of another species allied to *Carpolithes clipeiformis* Gein. (Verstein d. Steinkohlenformation in Sachsen, 1885, p. 43, Taf. 22, Fig. 28, A. B. C.)

20. A Fossil plant which may be compared with the *Spongillopsis dyadica* Gein., Dyas I., p. 132, Taf. 24, Fig. 2, from the Saxon Rothliegende, offers fewer generic points of similarity.

The before-described organic remains from the Variegated Marls near Manchester are distributed in the following Classes and Orders:—

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A. ANIMALS.

A. Conchifera.

1. *Schizodus Schlotheimi* Gein. — Characteristic fossil.
2. *Schizodus rotundatus* Brown sp. — Probably only variety of the preceding species.
3. *Schizodus obscurus* Sow. sp. — Rare.
4. ? *Edmondia elongata* Howse = *Edmondia Murchisoniana* King.
5. *Pleurophorus costatus* Brown sp. = *Arca costata* Brown.
6. *Clidophorus Pallasi* de Vern. sp. = *Cardiomorpha modioliformis* King.
7. *Aucella Hausmanni* Goldf. sp. = *Modiola acuminata* and *Mytilus squamosus* Sedgw.
8. *Avicula* (*Monotis*) *Kazanensis* de Vern. = *Avic. Kasanensis*. — Rare.
9. *Gervillia* (*Bakevellia*) *antiqua* Mün. sp. — Very abundant.

B. Gasteropoda.

10. *Natica minima* Brown.
11. *Turbo helicinus* Schl. sp., incl. *Turbo Mancunensis* Brown.
12. *Rissoa obtusa* Brown, incl. *Rissoa minutissima* Brown = *Turbo obtusus* Gein.
13. *Rissoa Gibsoni* Brown. Compare *Rissoa Leighi* Brown and *Turbonilla* (*Chemnitzia*) *Altenburgensis* Gein.
14. *Dentalium Speyeri* Gein. — Not *Dent. Sorbii* King.

C. Annulata.

15. *Vermilia obscura* King, incl. *Serpula pusilla* Var. a. Gein.
16. *Filograna Permiana* King, probably belonging to the Pteropoda.

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B. PLANTS.

A. CONIFERAE.

17 and 18. *Voltzia Liebeana* Gein. — ? *Ullmannia selaginoides* Bgt.

B. PALMAE.

19. *Guilielmites permianus* Gein.

C. ALGAE.

20. *Spongillopsis dyadica* Gein.

The totality of the fossil remains assigns this group of Variegated Marls to the Upper Zechstein or "Upper Magnesian Limestone" which is here partly represented by the Red and Green Marls, Clay Shales, and Sandstones, with interposed thin layers of Dolomitic Limestone or Nodules of the same.

This position has long ago been assigned to them by Sedgwick* (by Sir R. J. Murchison†) Binney, King, R. Howse and J. W. Kirkby, and H. B. Geinitz, Dyas II.

In the Upper Zechstein the Brachiopoda are absent here, as everywhere in Germany, unless one wishes to recognise in the doubtful *Filograna Permiana* King, the tubular spines of a *Strophalosia*.

The majority of the here-occurring species is principally, at least, attached to the Upper Zechstein, though some already make their appearance in the lower strata.

But we are not any longer dealing with a pure marine fauna, as still in the Middle and Lower Zechstein, but rather with irregular, alternating clayey and sandy coast deposits, mixed up between the calcareous marine deposits,

* Rev. A. Sedgwick on the Geol. Relations and internal Structure of the Magnesian-limestone Series. (Trans. of the Geol. Soc. of London, Second Ser., Vol. III., P. I., 1829, p. 37.)

† R. J. Murchison, Siluria, 1854, 1859, etc.

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with the last remains of the Permian or Dyassic fauna. The proved traces of land plants therein occurring as *Voltzia Liebeana* and *Guilielmites permianus* can only confirm this.

I have, in unison with C. F. Naumann and A. v. Gutbier, considered such mostly red-coloured deposits, which have been carried hither as a sandy clayey mud or as shingle from neighbouring coasts in the Zechstein Sea, as the time equivalents of the Zechstein and designated as Upper Rothliegende.

In Germany, in this way, the Lower and Middle Zechstein is generally only represented by the Upper Rothliegende, whilst the Upper Zechstein overlies both the Middle Zechstein (as Rauchwacke) as also the Upper Rothliegende.

There is, however, no rational ground against the idea that land, or coast formations of the Upper Rothliegende itself may not invade the regions of the Upper Zechstein.

This relation has resulted in the neighbourhood of Manchester, as also in different parts of Russia (*Etage tartarien* Nikitin*) in the variable nature in the Stage of the Upper Zechstein, and in the series of the Variegated Marls.

My conception of the Upper Rothliegende stands in opposition to the views of other authors on the Upper Rothliegende, and it is as a rule assumed that all Rothliegende must be older than Zechstein, whose lower members it should underlie.

Only the Lower and the Middle Rothliegende, which represent the true Lower Dyas or Lower Permian, are older than the whole series of the Zechstein down to the Weissliegende of Freiesleben or the Zechstein-Conglomerate of Beyrich.

Where such coast formations of the Dyas are directly succeeded by those often soon following similar formations of

* S. Nikitin, Recherches géologiques le long de la ligne du chemin de fer de Samara-Oufa. Zechstein et l'étage tartarien. 1887. 8°.—S. Nikitin, Bibliothèque géologique de la Russie, III., 1887, Nr. 23, 42.

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the Trias, that is to say, of the variegated sandstones as was the case in several parts of Germany, as well as near Manchester, a safe determination of their limit will not be always easy, and will give many an occasion for captious disputes of delimitations. Without wishing to enter more particularly into such discussions here, I would, however, point out, that also in England, erosions of the Upper Zechstein are known, very similar to those parts of Saxony and Thüringia described by me.* Compare the Section of Knottingley: Sedgwick a.a.O., p. 110, Pl. 4, Nr. 1 and Pl. 7, Fig. 6, and of Bedford: Binney a.a.O., 1885, p. 30.

Where it can be observed, that erosions, continuing for a long time, have converted the surface of the Upper Zechstein, especially of the Plattendolomites, into proper cliffs, before the red marls (Letten), have again filled up the gaps, there also appears, the boundary, very sharply marked, although, unfortunately, often hidden, between the Upper Zechstein and the lower members of the Variegated Sandstones.

Ingenious explanations, to which recourse has been had, in order to explain these phenomena by means of the subsequent action of dissolving waters, following the deposition of the variegated marls (Letten) at the boundary between the Zechstein and the Variegated Sandstone, I must, so far as the occurrences mentioned in "Leopoldina XXI.," are concerned, consider as abortive.

May my honoured geological colleagues in England succeed, even in the neighbourhood of Manchester, in obtaining still fresh evidence, in a similar mode, in order to gain further light as to the natural delimitation of the Permian system in its upper division, or, in other words, between the palæozoic Dyas and the mesozoic Trias!

* Geinitz, über die Grenzen der Zechsteinformation und der Dyas überhaupt. (Leopoldina, 1885, XXI.)—Zur Dyas in Hessen. (Fest-Schrift d. Ver. f. Naturkunde in Kassel. Kassel, 1886).

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ON THE MIDDLESBOROUGH SALT WORKS, AND THE RECENT BORING ON THE LACKENBY FORESHORE ESTATE.

By Mr. Thomas Bell, H.M. Inspector of Mines, Durham.

(Communicated by Mr. Joseph Dickinson, F.G.S.)

The Northern Salt industry has developed with remarkable rapidity since its establishment. At first in a modest way by Messrs. Bell Brothers, Limited, at Port Clarence, in the County of Durham, about the year 1884.

It has already become an important factor in the industrial life of Teesside, and hardly to a less extent in that of Tyneside, whose chemical works are no longer dependent upon the distant salt fields of Cheshire and Worcestershire, but now obtain their supplies of salt from the apparently exhaustless stores underlying the banks of the sister river.

Cleveland Salt is also fast superseding that of the Southern counties for the use in the East Coasts Fisheries, in Iceland, and in some of the North-West Ports of Europe, and has even been shipped round to the chemical works of the Clyde. It will not, therefore, be surprising to learn that the output during the past year nearly reached 220,000 tons, or rather more than the total consumption of salt by the Tyne chemical works.

It is expected that this quantity will in a short time be doubled, as these various works are being rapidly extended. Messrs. Tennant & Co. have recently put down four additional evaporating pans at Haverton Hill, with a view to making domestic or table salt, the adjoining works owned by the Salt Union being hitherto the only works where salt of this description was produced.

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The Cleveland Salt Co. have recently erected six large pans for the utilisation of the waste heat from the Middlesborough blast furnaces, and the Salt Union are at present erecting pans to be heated in like manner from the furnaces at Clarence Iron Works. The system of having the pans driven by waste heat from the blast furnaces is an advantage of which the full value can only be realised in times of dear fuel like the present.

At the end of the year 1889 there were 98 evaporating pans in work, and 22 in course of construction in this district.

Wharves are already being constructed on the Tees by some of the firms to facilitate the shipment of salt instead of sending it by rail.

The Salt Union have bored two additional wells during the past year for the supply of their pans, and Messrs. Bell Brothers are now boring two additional wells at Clarence for the supply of brine to their soda works.

The first boring was commenced by Messrs. Bolckow, Vaughan & Co., now merged into the Cleveland Salt Company, Limited, near to the docks at Middlesborough, in July, 1859, originally with a view to finding a supply of water for their iron and other works.

The bed of salt was reached in August, 1862, at a depth of 1206 feet from the surface, and proved to be 100 feet in thickness. This hole is taken as a base for the following holes bored on a line nearly due east on the south or Cleveland side of the River Tees as far as Lackenby, which is the east-most and deepest hole in the district where salt has been found.

The next in order was that of the Middlesbrough Estate Owners, who put down a well, in 1887, at North Ormesby

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(about half-a-mile south of the Middlesborough dock), and proved the salt, at a depth of 1341 feet, to be 79 feet in thickness, resting on 6 feet of anhydrous gypsum, with a bed of 10 feet of salt underneath. They are now boring a second well and erecting a large plant and evaporating pans at Cargo Fleet, where it is expected that salt-making will be commenced during the present spring.

At the Imperial Iron Works, about one and two-third miles east of Middlesborough dock, a well was bored and salt proved at a depth of 1574 feet, to be 86½ feet in thickness; this well has not yet been worked. The south bank well, owned by the Cleveland Salt Company, comes next in the line eastwards, and is about two miles east of their first well sunk near the Middlesborough docks. The salt was found here, at a depth of 1570 feet, to be 81 feet in thickness, and has been worked for the last three or four years. This company is now engaged putting down a second well, which is expected to be completed during the present month. The pans at this establishment are all driven by the waste heat from the south bank (Eston) blast furnaces.

Mr. T. C. Hutchinson and his partners, who own about 60 acres of reclaimed land, being part of the foreshore and bed of the River Tees, near to Lackenby, in the North Riding of York, determined to prove whether salt existed under their estate, and commenced to bore in July last, at a distance of one and one-eighth miles a little to the north and east of the south bank boring, and to the full dip of the measures. They entrusted the work to Messrs. Mather & Platt, of Manchester, who used the American or "chopping" type of boring machine, and proved the salt in November, at 1685 feet from the surface, to be 119 feet in thickness.

This American system of boring, as is well known to

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Mining Engineers, does not show the strata in cores as does the diamond borer.

The wells here enumerated are are all practically on the same surface level, being about on the high water line, except the hole bored at the Imperial Works, where they commenced in and bored through an old waste or slag heap for about 13½ feet.

The Lackenby boring was commenced at 12 inches diameter, and was lined with an iron tube of the same size for 87 feet. The hole was then reduced and lined with a 10 inch tube for 160 feet farther, when a further reduction took place and a lining of 8½ inches was put in for other 350 feet, making a total of 597 feet of tubing which reached the red rock. The remaining part of the hole was finished at 8½ inches diameter, and left without tubing.

From the position of this hole, being the furthest to the East and close under the shadow of the great Lias formation, composing the Cleveland Hills, which contain such valuable ironstone deposits on the South side, and within a very short distance of the Lias rocks at Redcar on the East, it was natural to suppose that this boring might have been commenced in the Lias formation, but this was proved to be an erroneous idea. The first (13 feet), or alluvial portion pierced was the ordinary deposit of sand clay, and gravel, washed in from the estuary by the tides before the embankment was thrown up. Underlying this were about 12 feet of ordinary red clay found throughout the district, then follow the usual red marls.

Many of our Mining Engineers, as well as myself, were curious to know whether or not the Lias overlies or overlaps the new red measures at this point, and a close examination was made of the material as it was brought out of the hole by the sand pump.

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This Company have not yet decided what system of evaporation they will adopt, but in the meantime have ordered all the necessary pumping machinery to be got ready, and it is expected that brine will be raised about mid-summer of this year, after which it is intended to put down several additional wells.

This important development of the Northern Salt deposit, together with the elaborate extensions of existing workings now being made, points to a very largely increased production of salt in this district at no distant date.

LACKENBY FORESHORE ESTATE SALT BORING.

Depth from Surface.			Thickness of Strata.		Description of Strata.
ft.	in.		ft.	in.	
13	0	..	13	0	Clay and Gravel.
24	8	..	11	8	Hard red clay and little gypsum.
87	0	..	62	4	Red marl and thin rock.
246	8	..	159	8	Red marl and bed of blue marl.
255	0	..	8	4	Bed of very hard rock.
343	0	..	88	0	Blue and red marl.
373	0	..	30	0	Dark red marl and blue stone.
380	0	..	7	0	Hard blue stone.
597	0	..	217	0	Red marl.
1195	0	..	598	0	Red sandstone.
1272	0	..	77	0	Red marl.
1643	0	..	371	0	Red marl and sandstone beds.
1663	3	..	20	0	Hard white rock.
1672	0	..	9	0	Honeycomb rock.
1685	0	..	13	0	Salt and marl mixed.
1804	0	..	119	0	Clean salt rock.
1806	0	..	2	0	White rock, bored two feet below salt.
			1806	0	

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Summary.

24	8	Top clay bed.
572	4	Marl and thin beds of stone.
598	0	Red sandstone.
448	0	Bottom marls.
42	0	Anhydrate beds.
119	0	Rock Salt.
1804	0	

Mr. Stirrup said: I have much pleasure in moving a vote of thanks to Mr. Dickinson for communicating the paper from Mr. Thomas Bell. I am sure it will be found extremely valuable when printed in our Transactions.

The motion was seconded by Mr. Crankshaw and passed.

Mr. Stirrup said: I should like to ask if the exact stratigraphical position of this salt rock is made out. Mr. Dickinson has certain views with regard to the position of these salt deposits; are these, in his opinion, on the same geological horizon as we find them at Northwich?

Mr. Dickinson: I wish Mr. De Rance had been here to-day; because, at the Society's meeting on the 12th November last he stated that he had that morning heard a piece of information as to this particular bore-hole. The boring, on the preceding day (he said) had reached the rock salt "at a point the most easterly of any borings in that district; and in that boring they had passed through the Lias and the whole series of underlying beds." Now, the paper which Mr. Bell has written states distinctly that they have not passed through any Lias; so that the actual proof of the Lias overlying the salt beds yet remains to be solved.

Mr. Stirrup: I know there was a difference of opinion with regard to the age of these Middlesborough salt beds at

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the British Association meeting at Newcastle. Professor Hull seemed to differ from some other authorities as to whether there were two horizons of salt in that district or only one.

Mr. DICKINSON: I see you said at that meeting, that Professor Hull stated that this was the only district in the British Islands where there were two geological horizons for salt—meaning, I presume, the Keuper and the Permian. Mr. De Rance, on the other hand, said that the salt measures of the Middlesborough area were all in one horizon—the Permian. There is no doubt that all the Middlesborough salt, as hitherto proved, lies above the Magnesian Limestone, which is called Permian. I call the marls in which the salt at Middlesborough lies the Saliferous Marls, and all the salt hitherto found there, lies above the Magnesian limestone.

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NOTICE TO MEMBERS.

The Members will be pleased to learn that a *new* Catalogue of the Library (which has been so long needed) is now in the course of preparation, and it is hoped that it will be ready for use and distribution at the commencement of the forthcoming session in October next.

June, 1890.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XX. SESSION 1889-90.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 9th, 1890, in the Mining School, Wigan.

Mr. County Alderman W. S. BARRETT, J.P., Vice-President, in the Chair.

NEW MEMBER.

The following gentleman was balloted for and duly elected an Ordinary Member of the Society:—

Mr. W. S. GRESLEY, F.G.S., Erie, Pa., U.S.A.

The CHAIRMAN announced that arrangements would shortly be made for an excursion to a part of the Manchester Ship Canal not previously visited by the Society, but the date had not yet been fixed. He then called on Mr. James Tonge to read a paper on

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NOTES ON COAL MEASURE FOSSILS.

Mr. TONGE said: Mr. Chairman and Gentlemen, I am afraid the few remarks I shall make this afternoon cannot be dignified by the title "Notes on Coal Measure Fossils," which appears in your notice of to-day's meeting, but rather an apology for such. When our esteemed Secretary (Mr. STIRRUP) a few months ago said to me and a friend that he wished he could induce members of the Society to be at a little trouble to preserve for the use of the Society any good fossils they met with, noting carefully the exact position they occupied in or near the mines, I at once collected a few from the Hulton Mines. But whilst so engaged the possible usefulness of the collection grew in my mind, and I conceived the larger idea of taking Mr. Dickinson's printed section of the "Coal Strata of Lancashire" (read before this Society in 1863); making from it sections to scale of the coal seams in the various Lancashire districts, and marking upon these sections the fossils found, with their exact horizon. Having thus got started, friends, who knew what I was doing, kindly began to send in such specimens as they thought might be interesting and useful, and these came in such numbers (especially after the project had been brought to the notice of the Lancashire Branch of the National Colliery Managers' Association), that, in accordance with the proverb, "Much will have more," I again set before me a larger aim, viz., to fill up the chart, if possible, with fossils from every seam from the top of the upper coal measures to the base of the lower. Meantime friends continued to send in specimens until I found I had a very considerable collection, and during the last few days, through the exceedingly kind manner in which a few

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gentlemen have interested themselves in the matter, the specimens have come in faster than I could arrange, label, and mark on the sections, and I have promises from other gentlemen of many more specimens. Under these circumstances, and as the fossils are intended to be given to the Society, or so many of them as they care to accept, I thought I should be excused if I delayed the reading of a paper and the showing of the fossils until the meeting at Manchester, when the fossils would be at home. I must add another word. During the collecting time I have found that the Ordnance Geological Surveyors have already obtained more fossils from the Lancashire coal fields than I was previously aware of, so that I may not be able to get together much that is really new, but perhaps I may, and I trust I shall, be able to bring together in a convenient form a considerable number of specimens, with their positions marked on a chart in such a way that it may easily be seen to what age they belong. Of course, the Ordnance Surveyors will have their fossils in their own possession, so that their having them does not lessen the necessity for our trying to get the same for our own Society, but should rather increase our desire to find such as they have, if we have not already got them. I am indebted to so many gentlemen for their kind assistance that I fear to trouble you with the list of names at this time, but the names of contributors will be found along with the names of fossils sent. I should esteem it a great favour if any member present, who has a fossil or fossils from the coal measures that he would like to present to the Society, would kindly entrust me with it, that I might mark it on the section in its proper place, and so help to fill up the series. Of course, I consider that they are not given to me, but to the Society, and they shall be carefully sent there. And so anxious am I to get the sections filled up, that if any gentleman has a coal measure fossil that he

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does not wish to part with, I should be glad to know its name and exact place in the strata, that it might at least be shown on the section. I feel sure that though the range of some of the shells and plants seems to be very considerable, (and so it will happen that a shell or plant does not always indicate with absolute certainty the exact place) colliery proprietors, managers, and others would not only derive pleasure but assistance by the aid of a pretty complete list of coal measure fossils and their places. The collection, so far, includes specimens ranging from the upper part of the Middle Coal Measures to the Lower Mountain Mine, and the localities embraced are Darwen, Bolton, Manchester, Tyldesley, Leigh, Wigan, and districts surrounding these towns. Of course I am aware that, after all, I shall be able to add only a *very little* information respecting our coal measure fossils; but I hope it will at least have the merit of being in a useful form.

ON A TREE BRANCH FOUND IN THE DRIFT.

Mr. G. H. Hollingworth exhibited a tree branch which he had found in the drift at a depth of forty (40) yards in the sinking of the Bredbury Collieries. The only peculiarity about the tree branch was the depth at which it was found in the drift, and that would go to show that the age of the drift was scarcely so great as mathematical geologists sometimes made out. The Sand bed in which the branch was found also contained many water-worn pieces of coal and cannel. The following was the section of strata passed through :—

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SECTION OF STRATA PASSED THROUGH IN SINKING THE No. 1 (DEEP) PIT AT LINGARD LANE, IN THE TOWNSHIP OF BREDBURY, FOR MESSRS. J. & R. STOTT-MILNE.

	Yds.	Ft.	Ins.
Clay	3	2	0
Marl	2	2	0
Quicksand	1	2	8
Marl with sand-beds and runners	6	1	0
Quicksand	0	1	3
Marl and sand	3	2	6
Strong marl	4	1	8
Soft foliated marl and sand	8	1	10
Soft marl	1	0	0
Strong stony marl	1	2	6
Sand	0	0	6
Strong stony marl	3	1	1
Sand	1	1	0
Marl	0	2	0
Sand (coal, cannel, and tree branch)	1	0	6
Wet loam	0	1	6
Strong stony red marl	4	1	7½

A vote of thanks to Mr. Hollingworth was unanimously passed.

A NEW FORM OF BELL FOR SIGNALLING IN COLLIERIES, RAILWAYS, &c., &c.

By Mr. G. S. Corlett, A.M.I.E.E.

The question of providing a simple, efficient, and reliable method of communication between two or more places being of such importance, the writer feels that no apology is

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necessary for introducing to the members of this Society an apparatus which is an improvement upon existing methods of signalling; but he must apologise for the somewhat disjointed and incomplete manner in which he is able now to bring the matter before them, owing to the short time at his disposal, it being only a week since he was asked to write this paper.

The principle involved in the bells is extremely simple, and hinges on the fact that by moving a coil of wire in the neighbourhood of a magnet a current of electricity is generated in the wire. It is precisely the same as that which holds good in all dynamo machines, with this difference of detail, that in dynamos the magnetic field is obtained from electro magnets, and in these bells from permanent steel magnets.

As will be seen from the samples on the table, there are two distinct parts of the apparatus, viz., the generator and the bell.

The generator (Fig. 1). is a small dynamo machine, and consists of a compound horse-shoe permanent steel magnet, fitted with soft iron pole pieces, between which is pivotted a soft iron H or Siemen's armature, wound longitudinally with insulated copper wire. In connection with this armature is the operating mechanism, consisting of a short arm attached to the spindle, terminating in a press button, which can be depressed by the finger against a retractive spring. By means of this mechanism the armature can easily be rotated backwards and forwards through an arc of about 30° or 40°, this motion generating a current of electricity in the armature wire, which is conveyed to the line wire, and so to the bell at the other end. No commutator is required, as the rotation does not extend through a complete circle; one end of the armature wrapping

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is connected to the iron core, and through that to the body of the instrument, and then to the earth terminal, the other end being joined to an insulated plug in the centre of the spindle, which runs against a contact spring joined to the

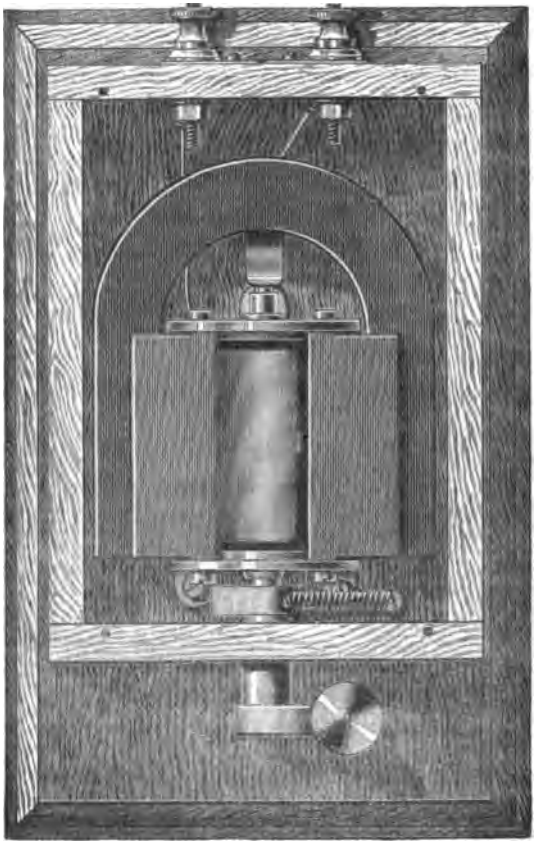

Fig. 1.

line terminal. For reply ringing on a single wire, as in shaft signal work, an automatic arrangement to cut the bell out of circuit at the moment of ringing is added (Fig. 3). This is effected by a spring working between two contacts, and

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which is connected direct to the line terminal, the bottom contact being joined to the bell, and the top one to the generator, the other ends of these latter apparatus going to earth terminal. At rest the bell contact is bearing firmly

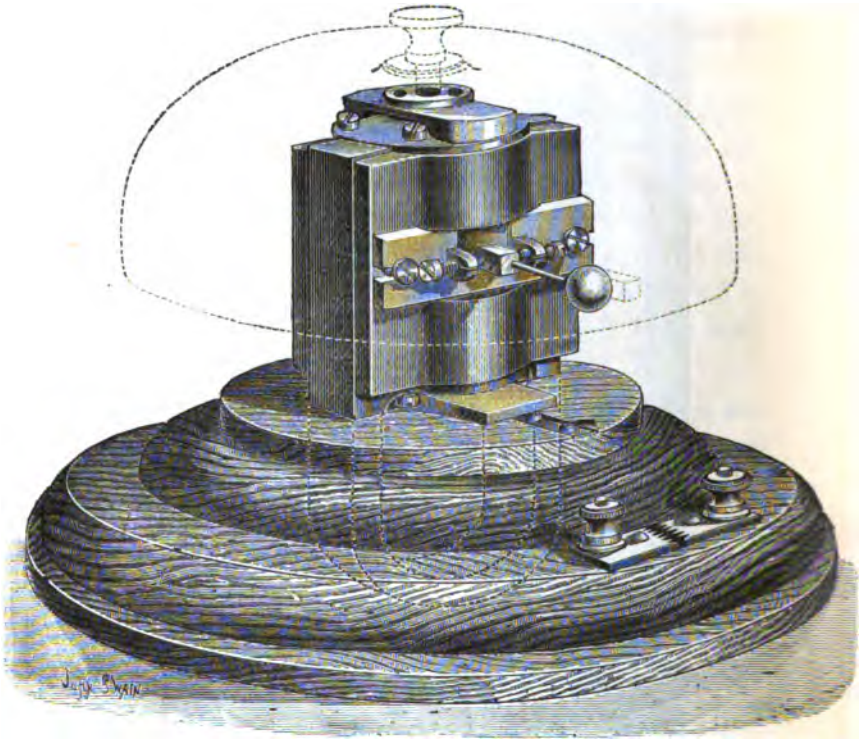

Fig. 2.

against the spring, the generator stud not touching the spring, so that a current being sent in from a generator at the distant end will pass direct to the bell and then to the earth. In ringing outwards, directly the lever begins to move, the bell contact is broken, and the spring comes up against the generator contact, so that the current generated

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by the motion of the armature can pass out to line, and thus to the bell at the far end.

The bell (Fig. 2) is almost exactly the same in construction as the generator, the dynamo with its armature and steel magnets being common to both. The spindle, however, in this case is vertical instead of horizontal, and carries an arm, terminating in a hammer head, which is arranged to strike

Fig. 3.

against a lug cast on the dome. The action in the bell is exactly the converse of that performed in the generator. The currents, which are induced in the armature of the generator by rotating it in a magnetic field, are conducted to the armature of the motor, and these currents cause this armature to revolve through the same proportion of a revolution, so striking the gong, and thus performing the work required of it.

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In fact, the system is merely the transmission of power by electricity from one point to another, the mechanical force exerted by the depression of the key on the generator being there converted into electrical energy, conveyed by wires to the motor on the bell, and there reconverted into the mechanical force which is used to strike the bell. After showing the type in which the generator and bell are combined in one case (Fig. 3), the writer proceeded. It might fairly be objected that in many exposed and trying situations, such as the bottom of a *wet colliery shaft*, the damp would speedily saturate the whole of the case with moisture, and so the current instead of doing its proper duty and ringing the bells on the surface, would find a short cut home through the moisture, and do no work at all. The writer has carefully considered this point, and has arranged that the spindle be led out through a gland, thus making the generator and its contents completely dust-proof, and that the entire generator be enclosed in an iron outer case, water-proof and dust-proof. He has seen the patentees, Messrs. Cox-Walker and Swinton, during the week, and they also consider that instruments made to his specification may safely be fixed in any place, no matter however wet it may be. The writer has connected up these bells on the table through half a mile of the kind of wire generally used for colliery signalling to make the conditions resemble as much as possible actual work.

In the ordinary form of signals worked by batteries there is a constant consumption of material, involving a certain amount of expense and attention, and if not properly looked after leading to a failure of the system. Further, in very wet places it is practically impossible to maintain the insulation of the whole system perfect, thus causing a constant drain on the batteries, which in many cases becomes a very serious matter, not only from the expense of new battery cells and zincs, but because the current tends

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to decompose the various substances in its path, and so the brass terminals, the connecting wires, &c., are corroded or eaten away, thus entirely stopping the working of the signals, and owing to its peculiar nature the fault is often very difficult to discover.

With magneto bells, as will have been seen, no expenditure of material takes place, the work being done by mechanical and not chemical energy; and except the repairs which may be necessary to the bearings, &c., of the generators, the instruments are practically everlasting, and they will work for a long time with no attention whatever. Further, as all the currents are momentary and only generated at the time of ringing, the electrolytic action which is found so harmful in battery signals on leaky circuits is entirely absent here.

Being so extremely simple, the liability to failure is reduced to a minimum, especially when it is remembered that the maximum power is always available. For shaft signal work and for communicating between any two distant points in a mine, these bells seem unrivalled, more particularly as in first cost they will compare favourably with battery signals, and the maintenance will be practically nothing; and in addition the speed by which signals can be transmitted seems only to be regulated by the rate at which a man can count, the writer having on several occasions obtained at least five blows per second.

As a rider to this paper, the writer would suggest the advisability of combining with the signal apparatus a system of telephonic communication, and to that end he shows a form of telephone which transmits speech clearly and distinctly up to distances of five or six miles, and which can be attached to ordinary shaft signals, using the existing wires and batteries; or in the case of magneto bells a small

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battery would have to be placed on the surface, while the magneto bells would be used to call. In case of accidents, and at many other times, it would be a great convenience to be able to speak from the top to the bottom. Also on engine planes, much time would be saved in many cases if a telephone was working from end to end of the road, or the underlooker could carry a receiver in his pocket, and from any point of the road he could by first ringing the signal for telephone, and then hooking his receiver to the wires, carry on a conversation with either end, the attendant at the end having previously received instructions that on receiving a certain signal he was to switch the telephone on and speak at once. The writer shows two forms of these instruments connected together, the current passing through half a mile of wire.

The CHAIRMAN: I may say we have heard with a great deal of interest the paper Mr. Corlett has read bearing upon the working of mines and increasing the means of communication both by signalling and telephone. There are several gentlemen here connected with mines and mining eminently qualified to speak upon the subject, and I should be glad if some of them will give us their views with regard to the paper they have heard.

Mr. J. L. HEDLEY: As far as I am concerned, Mr. Chairman, I am afraid I cannot say very much upon this subject, for I must confess I have not studied the question of electricity, and I am not in a position to compare the relative advantages of the two systems. This magneto is an entirely new thing to me. I have not seen or heard of magnets being used in this way, and therefore as to its advantages over the ordinary system or otherwise I am

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perfectly incapable of judging. It seems to me to be a simple thing, but it struck me when Mr. Corlett was making the experiments in the first instance that if the signals depended on the amount of force to be used by the operator at the one end, it might be liable to mistakes. Whether that is simply due to the unfinished state of the experiment, or whether it will occur in actual practice I cannot say, but it strikes me if it were to occur it might lead to very serious trouble on certain occasions. Perhaps Mr. Corlett will be able to tell us whether any of these magnetos are in actual use, and whether that difficulty has arisen. With regard to the telephone, it seems to me that something might be made out of that. It appears to me to be a very good idea. It very often happens that if you had a system of telephonic communication from point to point it would save a considerable amount of time and trouble, and if it could be adapted to the practical working of collieries I have no doubt it might have a future before it, and many colliery managers would be glad to make the experiment. I do not think they are backward in this district in experimenting with anything of this kind if there is any probability of its succeeding.

Mr. GRUNDY said there were one or two matters on which he would like Mr. Corlett's opinion. He had been careful to show many advantages, but he had perhaps left out many of the disadvantages of the apparatus. From what he understood of the apparatus they could only signal from end to end, and at those parts where the machine was. They could not signal from an intermediate place, where there was no machine. That was not so effective as where they had two wires, with a bell at each end of the plane, and were able to signal from any part of the plane. However long it was they could, with cells, signal at any part, and they had only to bring the wires together to signal

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at both ends. Mr. Corlett said the apparatus would wear for years without any attention; but he liked to take such remarks with a grain of salt. The oxidising action would take place and prevent that good contact that was necessary. The dirt getting on the apparatus would also prevent good contact. Then as to speaking, he did not quite see that the telephone need be made part and parcel of the signalling apparatus. It would be quite as easy to attach any other telephone to any other system of electric signalling. It would be well to emphasise Mr. Hedley's remarks as to the value of being able to communicate in words with those between the top and the bottom of the shaft, and that might be done in other ways than by electric signalling. He came across a manager who, in putting pipes down the pit, thought he would convert them into speaking tubes. He put 170 yards of piping between the engine-house and the bottom of the shaft, and he could converse quite easily. That was a system which might be carried out more than it was, and it would be less liable to get out of repair than a telephone, although a telephone would be useful in many cases. He did not quite understand whether in ringing from one end they could ring the bells at both ends, so that the person ringing would know almost exactly what signal he was giving to the other end, and whether he could hear his own bell ring the number of times. Then how many wires would be required for this system, and how many electro-magnetic machines?

Mr. CORLETT: In reply to the gentlemen who have just spoken, I should like to say a word or two. It is quite true as Mr. Hedley has pointed out that the force, with which the generator key at one end is depressed, will regulate the ringing of the bell, or in other words if the generator is moved slowly the bell will not ring at all. In actual practice however I think this would not be found either a

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difficulty or a probable cause of failure, and speaking after a very extensive experience in colliery signalling on the battery system my aim has been to make the apparatus so strong that the collier could not break it by pressing with all his force upon it, as he is in the habit of doing. Several of these magnet bells are in daily operation in collieries in Cumberland and Durham and have given every satisfaction to their users. If Mr. Grundy will read through my paper he will find that no where, do I say these bells are suitable for ordinary engine planes where it is essential that signals shall be transmitted from any point by merely pressing together the wires, but for shaft work and for communicating between any two or more points in the mine, I do claim that they are a decided advance on any previous method. I would also remind Mr. Grundy that the generator for underground work would be made quite dust-proof, and further that the only movable contacts, three in number, in the generator, are of platinum, a metal which does not readily oxidise. I think he will see that the apparatus is not very liable to failure on account of corrosion to the contacts, and without claiming absolute perfection for the apparatus, I am confident that the amount of attention it will require will be so small as practically to be negligible. I did not intend to say that a telephone is a necessary item in signalling apparatus, nor that this form is the only one that could be used, but I think it a very valuable adjunct to such a system, and that the type I show here both in efficiency and cost is eminently suited for the work. Speaking tubes can be used of course to transmit speech up to distances of say 400 yards, but the cost of fixing that length of say 2in. pipes would, I think, be considerably greater than for telephones. For longer distances I know of nothing but a telephone which is of practical use. In reply to Mr. Grundy's last query, the

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generators can be arranged to ring the bells at both ends simultaneously, and to accomplish this one line wire would be required.

The CHAIRMAN moved a vote of thanks to Mr. Corlett, which was duly seconded and passed.

The meeting then terminated.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XXI. VOL. XIX. SESSION 1889–90.

The ORDINARY and CONCLUDING MEETING of the Session was held on Tuesday, the 10th June, 1890, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

Mr. HENRY HALL, the President,

in the Chair.

ON THE ACTION OF CENTRIFUGAL FORCE WITH REGARD TO GEOLOGICAL PHENOMENA.

By Mr. THOMAS OLDHAM.

In this paper as in a previous one on the same subject *(See Part VI., Vol. XX., p. 128)*, the author contended that in the action of centrifugal force on our globe, must be sought the causes of some of the greatest phenomena of nature—as earthquakes, dislocation of the strata, and the different climatic changes that have taken place through all geological time. He said: "The cause why this globe has an elliptic form, was the foundation upon which all his theories were based. We know that this globe rotates upon its axis at the rate of about 26,000 miles every 24 hours, and rotation

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gives rise to centrifugal force which acts in a contrary direction to gravity, although it does not prevent gravity from acting also. Centrifugal force always acts at right angles to the equator. Rotation causing centrifugal force was the reason why this globe is elliptic, and rotation gives rise to the spiral motion, which is the cause of the overlapping of the strata, as it acts in a contrary direction to rotation."

Mr. Dickinson proposed that a vote of thanks be given to Mr. Oldham for the trouble he had taken in bringing this abstruse subject before the Society. This being seconded and passed.

Professor W. Boyd Dawkins criticised at some length the statements and views of the author, and said that he did not think as a Geological Society we had received any information whatever as to the action of centrifugal force with regard to geological phenomena.

Mr. Oldham, in reply to many adverse criticisms, said he should be glad to meet and discuss the subject with any gentleman taking an interest in the matters referred to.

THERMOMETRICAL OBSERVATIONS OF ATMOSPHERIC AIR AND WATER AT PIETHORN AND DENSHAW.

By Mr. William Watts, F.G.S.

The temperature observations of the atmospheric air and water taken at Piethorn and Denshaw have been in accordance with the instructions of the British Association Committee. The area and capacity of each reservoir remains unchanged, and the readings are taken daily at 9 a.m. A higher temperature both of atmospheric air and water is

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still maintained at Piethorn although the two valleys are near together, and similar in their geological substrata, and not much unlike in their physical conformation. Trees in both valleys are scarce and grow with difficulty, although in former times they appear to have flourished luxuriantly at a much higher elevation than we find them existing to-day. Excavating recently for the extension of our works at Castleshaw, Saddleworth, I counted 34 tree roots, more or less decomposed, in an area of 1,200 yards. Trunks and rootlets, in an incipient state of decomposition, are frequently dug up where ling and coarse grass only seem able to survive the present climatic conditions.

An atmosphere rendered impure by imperfect combustion of coal and other noxious vapours emitted from neighbouring manufactories is said to destroy trees and flowering plants on the Pennine slopes, but in my opinion the strong north-easterly winds, which prevail for weeks together with great force, year after year in early spring, are more destructive to the loftier trees than furnace gases diffused in the atmosphere. I am not speaking of tree life in a town where artificial precision in the growth of trees is aimed at, and where extensive manufactories are established, but of those on the Pennine slopes. I have many times seen the leaves and buds on the higher trees battered off the top branches, which must seriously interfere with their life.

Besides the atmospheric condition here alluded to the denudation of the land forming the hilly slopes of our country has much to answer for even during the life of a moderately sized tree. The upper portion of the root of an old tree in sloping ground is often seen bare and when its subsoil is removed its growth is impaired, and in time death ensues. The rate of denudation in sloping ground is more rapid than we imagine and the rootlets of trees shew it by the removal of the soily covering in which they were firmly rooted when saplings. In obedience to

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the law of gravitation soily material slowly moves down hill and never up. There is no return journey, and when assisted by atmospheric agencies—molecular expansion and contraction find the lines of least resistance, and rain, and excessive moisture, in time uncover fixed objects, such as rootlets of trees, and lay them bare. An examination of the tables shows that the water is warmer in winter and cooler in summer than the surrounding air consequently it must not be objectionable to reside on the margin of large reservoirs except an increase in the humidity of the air is a drawback.

In addition to the general tables, I have added a daily temperature table for the month.

AVERAGE DAILY TEMPERATURE.

1889. Month.	Pisthorn.		Denshaw.	
	Air.	Water.	Air.	Water.
June	59·6	58·1	60·8	58·7
July	57·8	59·8	57·5	59·8
August	56·5	58·2	54·9	57·6
September....	53·1	55·9	51·7	55·4
October	46·5	48·4	44·2	47·6
November	43·3	44·6	41·2	43·9
December	37·5	39·3	35·7	38·0
1890.				
January	39·2	39·0	37·9	38·7
February	35·1	37·1	34·4	36·3
March	40·8	38·6	39·1	38·0
April.....	44·1	42·9	41·9	42·4
May	52·6	49·8	50·6	49·9

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In order to make my observations as complete and interesting as possible, I have also added the monthly rainfall returns for each district, which I trust may be acceptable to the Society.

1889-90.	Rainfall at Pietthorn. Gauge 894 ft. above sea level.				Rainfall at Denshaw. Gauge 1,012 ft. above sea level.			
	Rain-fall.	Greatest fall in 24 hours.		No. of days on which rain fell.	Rain-fall.	Greatest fall in 24 hours.		No. of days on which rain fell.
	Inches.	Date.	Inches.		Inches.	Date.	Inches.	
June	0·61	2nd.	0·26	5	0·70	2nd.	0·38	5
July	3·92	21st.	0·67	17	4·47	21st.	0·83	16
August	6·55	5th.	0·82	23	7·73	5th.	1·18	22
September..	2·59	26th.	0·70	12	3·16	26th.	0·82	13
October	5·59	7th.	0·92	24	5·88	7th.	0·98	21
November..	1·83	24th.	0·46	15	2·37	24th.	0·54	15
December ..	3·16	21st.	0·84	18	2·66	21st.	0·65	17
January.....	5·65	26th.	1·68	27	4·80	21st.	1·12	27
February ..	0·73	15th.	0·45	9	0·88	15th.	0·56	7
March	3·87	23rd.	0·46	21	3·72	10th.	0·51	21
April.....	1·35	6th.	0·31	11	1·58	6th.	0·39	9
May	3·30	11th.	0·80	13	3·45	11th.	0·72	13

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
June 1	9 a.m.	55·4	53·6	Heavy Rain and Hail S.W.
,, 2	,,	57·2	53·5	,, ,, ,, S.E.
,, 3	,,	60·8	55·2	,, ,, ,, S.W.
,, 4	,,	60·0	56·1	Fine and Clear S.W.
,, 5	,,	66·1	57·9	,, ,, E.
,, 6	,,	62·1	55·8	,, ,, E.
,, 7	,,	60·2	58·2	,, ,, N.E.
,, 8	,,	60·2	58·3	,, ,, E.
,, 9	,,	53·6	57·3	Slight Rain E.
,, 10	,,	49·6	56·3	Slight Rain and Dull N.E.
,, 11	,,	50·7	55·6	Fine and Dull N.E.
,, 12	,,	58·2	57·6	Fine and Clear W.
,, 13	,,	61·5	57·0	,, ,, S.
,, 14	,,	55·0	58·0	,, ,, S.
,, 15	,,	61·0	58·9	Slight Rain S.
,, 16	,,	60·1	58·3	Fine and Clear S.W.
,, 17	,,	65·0	58·9	,, ,, S.
,, 18	,,	67·8	60·8	,, ,, S.E.
,, 19	,,	52·7	58·0	Fine and Dull N.E.
,, 20	,,	57·3	58·4	Fine and Clear N.E.
,, 21	,,	54·2	58·0	Fine and Dull N.E.
,, 22	,,	67·9	59·9	Fine and Clear N.W.
,, 23	,,	54·5	58·1	Slight Rain N.E.
,, 24	,,	55·6	58·1	Fine and Clear E.
,, 25	,,	58·4	58·6	,, ,, N.E.
,, 26	,,	67·0	60·6	,, ,, S.W.
,, 27	,,	65·1	60·9	,, ,, S.W.
,, 28	,,	66·9	61·5	,, ,, W.
,, 29	,,	63·0	61·5	,, ,, W.
,, 30	,,	60·5	61·6	Fine and Dull S.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
July 1	9 a.m.	60·9	61·3	Fine and Clear	S.W.
,, 2	,,	64·2	63·2	,, ,,	E.
,, 3	,,	55·9	60·5	,, ,,	N.E.
,, 4	,,	60·5	61·0	Fine and Dull	N.E.
,, 5	,,	60·0	60·7	Fine and Clear	N.E.
,, 6	,,	63·9	61·1	,, ,,	W.
,, 7	,,	56·0	61·4	Slight Rain	W.
,, 8	,,	54·5	60·8	Fine and Clear	W.
,, 9	,,	59·4	60·5	,, ,,	W.
,, 10	,,	65·0	61·9	Slight Rain	E.
,, 11	,,	59·0	60·9	Heavy Rain	S.W.
,, 12	,,	61·3	61·2	Fine and Clear	N.E.
,, 13	,,	56·2	60·0	Slight Rain	E.
,, 14	,,	54·7	59·9	,, ,,	W.
,, 15	,,	52·6	59·5	,, ,,	S.W.
,, 16	,,	52·8	59·2	,, ,,	S.W.
,, 17	,,	57·3	60·0	,, ,,	N.W.
,, 18	,,	51·2	59·1	,, ,,	S.W.
,, 19	,,	51·6	58·3	Fine and Dull	S.W.
,, 20	,,	57·6	58·6	Fine and Clear	S.
,, 21	,,	54·6	58·3	Heavy Rain	S.
,, 22	,,	54·3	58·0	,, ,,	W.
,, 23	,,	55·9	58·3	Slight Rain	S.W.
,, 24	,,	55·3	58·0	Heavy Rain	S.
,, 25	,,	51·6	57·9	,, ,,	S.W.
,, 26	,,	54·1	57·7	,, ,,	S.W.
,, 27	,,	59·0	58·3	,, ,,	W.
,, 28	,,	55·9	58·7	Fine and Clear	S.W.
,, 29	,,	61·5	59·6	Slight Rain	S.W.
,, 30	,,	66·7	60·0	Fine and Clear	S.W.
,, 31	,,	69·8	61·4	,, ,,	S.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Aug. 1	9 a.m.	63·5	62·7	Fine and Clear S.W.
,, 2	,,	61·1	62·0	,, ,, S.W.
,, 3	,,	60·0	60·9	Heavy Rain S.W.
,, 4	,,	60·1	60·3	,, ,, S.W.
,, 5	,,	59·8	59·0	Slight S.W.
,, 6	,,	51·8	58·7	Heavy Rain S.W.
,, 7	,,	56·5	59·2	,, ,, S.W.
,, 8	,,	58·9	59·2	,, ,, S.W.
,, 9	,,	54·8	58·9	Slight S.W.
,, 10	,,	53·3	58·5	Heavy S.W.
,, 11	,,	52·8	58·6	Slight N.E.
,, 12	,,	53·8	58·8	,, N.W.
,, 13	,,	56·3	58·7	Fine and Clear S.W.
,, 14	,,	53·1	58·0	Slight Rain S.W.
,, 15	,,	57·6	58·1	Heavy Rain S.W.
,, 16	,,	59·3	58·3	Slight Rain and Dull S.W.
,, 17	,,	57·4	58·3	Heavy Rain S.W.
,, 18	,,	57·8	58·0	Slight S.W.
,, 19	,,	61·0	58·2	Fine and Clear E.
,, 20	,,	57·2	58·0	Heavy Rain and Dull S.W.
,, 21	,,	54·7	57·3	Heavy Rain S.W.
,, 22	,,	52·7	57·3	Heavy Rain and Dull W.
,, 23	,,	53·0	56·9	Slight Rain S.W.
,, 24	,,	54·0	56·8	Heavy Rain and Dull S.W.
,, 25	,,	49·3	56·0	,, ,, Hail S.W.
,, 26	,,	51·4	56·7	Slight Rain and Dull N.W.
,, 27	,,	55·0	56·3	,, ,, S.W.
,, 28	,,	56·1	56·0	,, ,, S.W.
,, 29	,,	58·4	56·3	Fine and Clear S.W.
,, 30	,,	59·9	56·6	,, ,, S.W.
,, 31	,,	61·4	56·9	,, ,, E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature. Air.	Temperature. Water.	Remarks on Weather, &c.	
Sept. 1	9 a.m.	56·0	57·0	Fine and Clear	E.
,, 2	,,	58·1	56·6	,, ,,	E.
,, 3	,,	57·4	57·0	Slight Rain and Dull	E.
,, 4	,,	57·4	57·0	Damp, Misty	E.
,, 5	,,	55·9	57·0	,, ,,	N.E.
,, 6	,,	58·1	57·2	Fine and Clear	N.E.
,, 7	,,	56·0	57·1	,, ,,	N.E.
,, 8	,,	58·5	57·5	,, ,,	N.E.
,, 9	,,	59·2	57·9	,, Dull	S.W.
,, 10	,,	62·2	58·0	,, ,,	S.W.
,, 11	,,	61·2	58·2	,, ,,	S.W.
,, 12	,,	60·9	59·1	Slight Rain and Misty	N.W.
,, 13	,,	57·9	59·5	,, ,,	N.W.
,, 14	,,	52·0	57·9	Damp, Misty	E.
,, 15	,,	50·2	57·6	Slight Rain	N.E.
,, 16	,,	54·0	57·5	Fine and Clear	S.
,, 17	,,	52·6	57·1	,, ,,	S.W.
,, 18	,,	53·7	56·6	,, ,,	S.W.
,, 19	,,	50·0	56·0	Slight Rain	S.W.
,, 20	,,	47·0	55·4	Stormy, Rain	S.W.
,, 21	,,	44·9	54·8	,, and Hail	S.W.
,, 22	,,	43·2	54·2	,,	W.
,, 23	,,	45·4	53·7	Fine and Dull	S.W.
,, 24	,,	47·1	52·9	Stormy, Rain	N.E.
,, 25	,,	42·6	52·8	Slight Rain and Dull	N.W.
,, 26	,,	47·0	52·3	Fine, but Dull	S.W.
,, 27	,,	56·9	53·1	Heavy Rain and Dull	S.W.
,, 28	,,	50·4	52·6	,, ,,	W.
,, 29	,,	46·3	52·1	Fine and Gloomy	W.
,, 30	,,	50·6	52 0	Stormy, Rain	N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Oct. 1	9 a.m.	47·8	51·7	Slight Rain N.E.
,, 2	,,	50·0	51·4	Showery N.E.
,, 3	,,	50·0	51·2	Slight Rain and Dull E.
,, 4	,,	48·7	50·9	Stormy, Rain, & Dull N.E.
,, 5	,,	48·0	50·9	Fine, but Dull S.
,, 6	,,	47·5	50·8	Slight Rain S.
,, 7	,,	47·2	50·4	Heavy Rain and Dull S.W.
,, 8	,,	45·0	49 6	,, ,, ,, S.W.
,, 9	,,	44·1	48 7	Stormy, Rain & Hail S.W.
,, 10	,,	46·0	48·9	Stormy and Dull S.W.
,, 11	,,	51·9	49·1	,, ,, S.W.
,, 12	,,	45·8	48·8	Slight Rain & Foggy S.W.
,, 13	,,	46·9	48·9	,, ,, ,, S.W.
,, 14	,,	43·1	48·8	Fine, but Foggy S.W.
,, 15	,,	49·8	48·6	,, ,, S.
,, 16	,,	48·9	48 9	Slight Rain and Dull N.W.
,, 17	,,	47·3	48·5	Showery and Foggy W.
,, 18	,,	50·4	48·7	Fine and Foggy E.
,, 19	,,	47·9	48·3	Slight Rain and Dull E.
,, 20	,,	46·9	47·7	Heavy Rain E.
,, 21	,,	46·2	47·7	Slight Rain and Dull E.
,, 22	,,	46·0	47·8	Heavy Rain N.E.
,, 23	,,	45·8	47·4	,, ,, N.E.
,, 24	,,	45·4	47·2	Slight Rain N.E.
,, 25	,,	42·0	46·2	,, ,, N.E.
,, 26	,,	39·9	45·8	Slight Rain and Dull N.E.
,, 27	,,	40·4	45·3	Stormy, Rain & Dull N.E.
,, 28	,,	44·7	45·4	Stormy and Rain N.E.
,, 29	,,	46·5	45·7	Slight Rain & Foggy S.W.
,, 30	,,	49·0	45·9	Fine, but Dull S.
,, 31	,,	43·9	45·4	Stormy, Rain and Dull S.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Nov. 1	9 a.m.	44·7	45·2	Stormy, Rain and Dull S.
,, 2	,,	42·0	44·9	,, ,, Hail S.W.
,, 3	,,	45·8	45·0	Heavy Rain S.
,, 4	,,	45·0	45·2	Heavy Rain and Dull W.
,, 5	,,	40·2	44·3	Fine, White Frost S.W.
,, 6	,,	45·4	44·8	Damp, Foggy S.W.
,, 7	,,	48·0	45·0	,, ,, S.W.
,, 8	,,	48·4	45·5	Slight Rain and Dull S.W.
,, 9	,,	48·6	45·7	,, ,, ,, S.W.
,, 10	,,	48·8	45·8	Fine, but Dull S.W.
,, 11	,,	47·8	46·0	Damp, Foggy W.
,, 12	,,	48·5	46·0	Fine, but Dull S.
,, 13	,,	43·2	44 9	Fine and Frosty E.
,, 14	,,	47·0	45·1	Fine, but Dull S.E.
,, 15	,,	50 5	45·7	Slight Rain and Dull S.
,, 16	,,	49·8	46·0	,, ,, S.W.
,, 17	,,	42·9	45·2	Fine, but Dull S.W.
,, 18	,,	48·4	45·5	Fine and Clear E.
,, 19	,,	47·7	45·4	,, ,, E.
,, 20	,,	39·0	45·2	Fine, but Dull S.E.
,, 21	,,	39·0	44·5	,, ,, S.
,, 22	,,	47·1	44·7	,, ,, S.
,, 23	,,	44·8	45·1	Slight Rain and Dull S.W.
,, 24	,,	43·9	44·9	Fine, but Dull S.
,, 25	,,	40·2	44·2	Stormy, Rain, and Hail W.
,, 26	,,	33·8	43·1	Slight Snow & Dull S.W.
,, 27	,,	27·9	42·6	Stormy Snow & Hail N.W.
,, 28	,,	28·8	41·7	Fine, Clear, Frosty N.W.
,, 29	,,	36·1	41·6	Fine, but Foggy S.W.
,, 30	,,	37·8	41·7	Slight Rain and Foggy E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Dec. 1	9 a.m.	37·0	41·2	Fine and Clear S.W.
,, 2	,,	33·0	40·8	Fine, Clear and Frosty E.
,, 3	,,	32·8	40·0	,, ,, ,, E.
,, 4	,,	33·0	39·7	,, ,, ,, N.E.
,, 5	,,	33·8	39·7	Slight Snow & Dull N.E.
,, 6	,,	37·0	40·0	Fine and Clear S.
,, 7	,,	35·6	38·6	Heavy Snow & Foggy S.
,, 8	,,	35·5	38·9	Fine, but Dull E.
,, 9	,,	45 5	40·1	Heavy Rain & Dull S.W.
,, 10	,,	40·9	39·9	,, ,. Hail S.W.
,, 11	,,	32·4	38·9	Stormy, Rain and Hail N.
,, 12	,,	32·1	38·4	Slight Snow and Dull S.
,, 13	,,	39·1	38·6	Slight Rain and Dull S.
,, 14	,,	30·9	38·6	Fine White Frost E.
,, 15	,,	40·0	38·2	Fine, but Foggy E.
,, 16	,,	44·0	39·1	Damp Mist S.W.
,, 17	,,	49·9	40·3	Slight Rain & Foggy S.W.
,, 18	,,	47·8	40·8	Slight Rain and Dull S.W.
,, 19	,,	38·5	39·4	Heavy Rain and Dull S.W.
,, 20	,,	36·4	39·6	Sleet and Rain S.W.
,, 21	,,	35·6	38·8	,, ,, S.W.
,, 22	,,	45·6	39·8	Heavy Rain & Misty S.W.
,, 23	,,	43·0	39·9	,, ,, ,, S.W.
,, 24	,,	43·9	40·8	,, ,, ,, N.W.
,, 25	,,	38·3	39·7	Slight Rain S.W.
,, 26	,,	42·3	39·8	Fine, but Dull S.W.
,, 27	,,	37·7	39·7	Fine and Clear S.E.
,, 28	,,	29·0	38·3	Fine, and Clear Frosty E.
,, 29	,,	30·0	37·9	,, ,, ,, E.
,, 30	,,	28·3	37·7	,, ,, ,, E.
,, 31	,,	33·6	36·8	Fine White Frost S.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1890. Date.		Hour.	Temperature.		Remarks on Weather, &c.	
			Air.	Water.		
Jan.	1	9 a.m.	36·2	37·3	Damp, Mist	S.W.
,,	2	,,	31·4	36·8	Fine White Frost	E.
,,	3	,,	20·0	36·4	,, and Clear	N.E.
,,	4	,,	40·0	36·9	Sleet, Rain	S.W.
,,	5	,,	46·3	38·0	Showery, Dull	S.W.
,,	6	,,	43·0	38·0	,, ,,	S.W.
,,	7	,,	50·8	40·1	,, ,,	S.
,,	8	,,	46·1	40·1	,, ,,	S.
,,	9	,,	38·1	39·0	,, ,,	S.W.
,,	10	,,	41·9	39·8	Heavy Rain	S.W.
,,	11	,,	41·0	39·9	Slight ,, and Misty	S.W.
,,	12	,,	41·5	39·9	Heavy ,, ,,	S.W.
,,	13	,,	46·8	40·3	Slight ,, ,,	S.W.
,,	14	,,	38·8	39·6	Fine and Clear	S.
,,	15	,,	37·8	40·1	Slight Rain and Dull	S.
,,	16	,,	48·2	41·0	,, ,, Misty	S.
,,	17	,,	46·2	41·4	Fine but Dull	S.
,,	18	,,	39·3	40·9	Slight Rain and Dull	S.W.
,,	19	,,	41·6	40·4	,, ,, ,,	S.W.
,,	20	,,	34·5	39·4	Hail and Stormy	S.W.
,,	21	,,	33·6	38·8	Slight Snow	S.W.
,,	22	,,	33·5	38·9	Heavy Snow and Rain	S.W.
,,	23	,,	32·5	37·9	,, ,,	N.E.
,,	24	,,	35·8	38·0	Slight ,,	S.W.
,,	25	,,	47·6	39·9	Heavy Rain	S.W.
,,	26	,,	38·9	38·8	Stormy, ,, and Hail	S.W.
,,	27	,,	37·1	38·7	Heavy ,, ,,	S.W.
,,	28	,,	33·4	37·7	Slight Snow	N.E.
,,	29	,,	27·3	37·9	Sleet and Snow	S.E.
,,	30	,,	41·4	38·6	Slight Rain	S.W.
,,	31	,,	44·9	39·3	Rain and Misty	S.W.

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OBSERVATIONS, PIETHORN.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Feb. 1	9 a.m.	45·0	39·9	Damp, Misty S.W.
,, 2	,,	37·9	39·2	Fine and Clear W.
,, 3	,,	39·0	39·3	Fine and Dull S.W.
,, 4	,,	39·0	39·2	,, but Dull S.W.
,, 5	,,	38·3	39 1	,, ,, N.E.
,, 6	,,	29·9	38·9	Fine and Clear N.
,, 7	,,	36·8	38·7	Slight Rain N.E.
,, 8	,,	30·0	37·8	Fine and Clear N.E.
,, 9	,,	34·9	37·9	Slight Snow N.E.
,, 10	,,	32·7	37·5	,, ,, N.E.
,, 11	,,	29·9	37·1	Fine, but Misty N.E.
,, 12	,,	30·9	36·8	Fine and Clear E.
,, 13	,,	30·2	36·1	,, ,, E.
,, 14	,,	31·2	35·9	Slight Snow E.
,, 15	,,	35·5	36·4	Sleet and Rain E.
,, 16	,,	35·1	36·0	Heavy Snow and Dull S.
,, 17	,,	37·0	36·3	Fine, but Dull E.
,, 18	,,	35·9	36·4	Damp, Mist N.E.
,, 19	,,	34·6	36·3	Fine, but Dull N.E.
,, 20	,,	32·2	36·0	Slight Snow and Dull E.
,, 21	,,	37·2	36·0	,, ,, E.
,, 22	,,	36·8	35·9	White Frost & Foggy E.
,, 23	,,	31·6	35·7	,, ,, ,, E.
,, 24	,,	41·3	36·2	Slight Rain and Dull N.E.
,, 25	,,	37·2	36·1	Slight Rain N.E.
,, 26	,,	39·6	36·6	Fine and Clear N.E.
,, 27	,,	33·0	36·2	Showery, Rain N.
,, 28	,,	30·5	35·0	Fine and Clear Frost N.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Mar. 1	9 a.m.	34·8	35·6	Slight Snow and Dull W.
,, 2	,,	28·9	35·2	Slight Snow N.E.
,, 3	,,	25·0	34·8	,, ,, E.
,, 4	,,	28·0	34·6	Fine and Frosty S.
,, 5	,,	36·1	33·6	Sleet, Rain and Dull W.
,, 6	,,	42·4	36·3	Slight Rain and Dull S.W.
,, 7	,,	43·7	36·7	,, ,, ,, S.W.
,, 8	,,	39·5	36·6	,, ,, ,, S.
,, 9	,,	31·0	35·6	Stormy, Hail & Snow W.
,, 10	,,	46·2	37·0	Heavy Rain & Misty S.W.
,, 11	,,	46·8	38·2	Heavy Rain & Dull S.W.
,, 12	,,	47·9	39·1	Fine, but Dull S.W.
,, 13	,,	43·5	38·8	,, ,, S.W.
,, 14	,,	41·2	39·0	Slight Rain and Dull S.
,, 15	,,	44·2	39·3	,, ,, ,, S.
,, 16	,,	52·0	40·7	Fine and Clear S.E.
,, 17	,,	36·2	39·2	Sleet and Rain S.W.
,, 18	,,	41·3	39·5	Stormy, Rain and Hail E.
,, 19	,,	38·2	39·6	Fine, but Dull N.E.
,, 20	,,	35·6	39·2	Sleet and Rain N.W.
,, 21	,,	38·4	39·5	Sleet, Rain and Dull S.W.
,, 22	,,	40·7	39·6	Slight Rain & Foggy W.
,, 23	,,	43·4	40·2	Slight Rain S.
,, 24	,,	41·6	40·0	Heavy Rain E.
,, 25	,,	43·4	40·0	Showery and Dull S.W.
,, 26	,,	45·6	40·4	,, ,, S.W.
,, 27	,,	49·1	41·2	Heavy Rain & Dull S.W.
,, 28	,,	50·5	42·2	Slight Rain and Dull S.
,, 29	,,	43·8	42·2	Fine, but Dull S.W.
,, 30	,,	43·4	41·8	,, ,, S.W.
,, 31	,,	43·9	42·1	Fine and Clear N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
April 1	9 a.m.	42·2	42·1	Fine, White Frost S.E.
,, 2	,,	45·9	42·0	,, ,, ,, E.
,, 3	,,	47·4	42·2	,, ,, ,, S.E.
,, 4	,,	45·3	42·2	,, ,, ,, E.
,, 5	,,	47·3	43·0	,, ,, ,, S.
,, 6	,,	43·4	42·9	Slight Rain and Dull S.W.
,, 7	,,	43·5	43·0	Heavy ,, Hail S.W.
,, 8	,,	42·2	43·0	Stormy ,, ,, W.
,, 9	,,	41·7	43·0	Hail Storms N.
,, 10	,,	39·6	42·9	Slight Snow N.
,, 11	,,	38·9	43·0	,, White Frost N.
,, 12	,,	39·0	43·0	Stormy, Sleet, and Rain S.
,, 13	,,	37·1	42·7	Slight Snow and Frost E.
,, 14	,,	41·3	42·2	Fine, White Frost E.
,, 15	,,	41·3	42·4	Slight Rain N.E.
,, 16	,,	43·6	42·3	,, ,, and Dull N.E.
,, 17	,,	42·2	42·3	Damp, Mist E.
,, 18	,,	39·8	42·0	,, ,, E.
,, 19	,,	43·3	42·4	,, ,, E.
,, 20	,,	50·6	42·1	Fine, but Dull S.
,, 21	,,	48·8	42·7	,, ,, S.
,, 22	,,	48·8	43·0	Showery, ,, S.W.
,, 23	,,	45·2	43·0	,, Rain and Hail S.W.
,, 24	,,	43 9	43·3	,, and Dull S.W.
,, 25	,,	45·3	43·6	,, White Frost S.W.
,, 26	,,	45·5	44·9	Sleet and Rain N.E.
,, 27	,,	44·9	43·7	Showery and Dull W.
,, 28	,,	41·2	43·9	,, Misty E.
,, 29	,,	47·8	44·5	Fine and Clear E.
,, 30	,,	56·5	45·1	,, ,, S.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, PIETHORN.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
May 1	9 a.m.	48·6	44·7	Fine, but Misty N.E.
,, 2	,,	55·2	46·6	Fine and Clear S.
,, 3	,,	54·9	46·2	Stormy, Showery, Dull S.E.
,, 4	,,	56·5	46·3	Fine, Clear E.
,, 5	,,	48·4	47·0	Damp, Mist N.E.
,, 6	,,	53·8	48·2	Showery and Dull N.E.
,, 7	,,	55·0	48·2	,, ,, E.
,, 8	,,	49·2	48·0	Fine, but Dull E.
,, 9	,,	47·8	48·1	Stormy and Dull E.
,, 10	,,	50·5	48·6	,, ,, S.E.
,, 11	,,	48·4	48·2	,, ,, N.E.
,, 12	,,	53·2	49·3	Heavy Rain S.W.
,, 13	,,	49·2	49·3	Showery and Dull E.
,, 14	,,	48·6	49·5	Fine, but Dull S.W.
,, 15	,,	46·8	48·8	Showery and Dull S.W.
,, 16	,,	48·4	49·0	,, ,, S.
,, 17	,,	51·6	49·8	Heavy Rain S.W.
,, 18	,,	54·4	49·8	Showery and Dull E.
,, 19	,,	57·0	50·4	Fine and Clear E.
,, 20	,,	56·8	50·6	Showery and Dull E.
,, 21	,,	55·5	50·7	Fine and Clear S.W.
,, 22	,,	60·0	51·9	Fine, but Dull S.W.
,, 23	,,	60·6	51·5	Fine and Clear E.
,, 24	,,	61·4	51·7	,, ,, E.
,, 25	,,	60·5	53·0	,, ,, E.
,, 26	,,	49·1	52·7	,, ,, N.E.
,, 27	,,	48·1	52·3	,, ,, E.
,, 28	,,	53·0	53·0	Fine, but Dull S.W.
,, 29	,,	51·8	53·6	Fine and Clear W.
,, 30	,,	50·9	53·1	Heavy Rain W.
,, 31	,,	47·3	53·9	Fine and Clear N.W.

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OBSERVATIONS, DENSHAW.

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
June 1	9 a.m.	56·0	53·0	Fine and Warm S.W.
,, 2	,,	58·9	54·0	Thunderstorms S.E.
,, 3	,,	61·3	54·9	Fine and Warm W.
,, 4	,,	57·4	55·3	,, ,, S.W.
,, 5	,,	64·5	57·1	,, ,, E.
,, 6	,,	59·0	56·7	,, ,, E.
,, 7	,,	67·5	58·5	,, ,, E.
,, 8	,,	56·6	58·2	Thunder, Rain E.
,, 9	,,	62·0	58·0	Dull and Rain E.
,, 10	,,	49·0	56·7	Cold Wind and Fine E.
,, 11	,,	48·8	55·8	,, ,, E.
,, 12	,,	60·5	57·0	Fine and Warm E.
,, 13	,,	66·7	58·0	,, ,, W.
,, 14	,,	58·5	58·7	,, ,, S.W.
,, 15	,,	66·2	59·9	,, ,, S.W.
,, 16	,,	65·8	59·9	,, ,, W.
,, 17	,,	69·7	60·8	,, ,, W.
,, 18	,,	66·9	61·9	,, ,, E.
,, 19	,,	50·4	59·5	Very Hot E.
,, 20	,,	55·1	58·9	,, ,, E.
,, 21	,,	53·0	59·0	,, ,, E.
,, 22	,,	70·0	61·1	Fine and Dull E.
,, 23	,,	57·8	59·6	,, ,, E.
,, 24	,,	54·6	59·5	,, ,, E.
,, 25	,,	55·8	59·4	,, Warm (Hot) E.
,, 26	,,	69·0	60·6	,, ,, ,, S.E.
,, 27	,,	70·2	61·5	,, ,, ,, S.
,, 28	,,	67·1	63·1	,, ,, ,, W.
,, 29	,,	63·0	63·3	,, ,, W.
,, 30	,,	63·4	62·6	,, ,, W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
July 1	9 a.m.	66·5	61·5	Fine and Warm	N.E.
,, 2	,,	62·8	63·1	Very Hot	E.
,, 3	,,	54·3	61·7	,, ,,	E.
,, 4	,,	59·0	61·0	Dull and Fine	E.
,, 5	,,	57·8	60·7	Fine and Warm	E.
,, 6	,,	67·6	61·5	,, ,,	S.W.
,, 7	,,	58·2	61·9	Dull and Rain	W.
,, 8	,,	62·0	61·9	,, Fine	W.
,, 9	,,	58·8	61·0	,, Rain	E.
,, 10	,,	63·5	61·1	,, Stormy	S.W.
,, 11	,,	56·2	60·9	,, Fine	W.
,, 12	,,	59·0	61·2	,, Stormy	E.
,, 13	,,	55·0	60·7	,, ,,	E.
,, 14	,,	54·2	60·0	,, ,,	S.W.
,, 15	,,	53·4	60·0	,, ,,	W.
,, 16	,,	50·0	59·8	Thunderstorms	W.
,, 17	,,	58·1	59·7	Dull and Stormy	S.W.
,, 18	,,	53·5	59·2	,, Cold Wind	W.
,, 19	,,	51·3	58·2	,, ,,	W.
,, 20	,,	55·6	58·2	,, Stormy	S.
,, 21	,,	56·4	58·1	Thunderstorms	S.W.
,, 22	,,	54·6	57·8	,,	W.
,, 23	,,	53·9	57·6	,,	S.W.
,, 24	,,	52·7	57·4	Dull and Stormy	S.W.
,, 25	,,	49·0	57·1	,, ,,	W.
,, 26	,,	54·1	57·0	,, ,,	N.
,, 27	,,	53·8	57·0	Fine and Warm	N.
,, 28	,,	55·7	57·6	Dull and Stormy	W.
,, 29	,,	61·6	58·8	Fine and Warm	W.
,, 30	,,	66·2	60·9	,, ,,	S.W.
,, 31	,,	67·3	62·0	,, ,,	S.W.

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OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Aug. 1	9 a.m.	64·7	63·0	Dull and Showery S.W.
,, 2	,,	60·0	62·2	Thunder Showers W.
,, 3	,,	58·0	60·8	Dull and Showery W.
,, 4	,,	59·0	60·4	,, ,, W.
,, 5	,,	57·5	60·1	Thunder Showers S.
,, 6	,,	50·0	59·0	,, ,, S.W.
,, 7	,,	53·0	58·0	Dull and Showery W.
,, 8	,,	55·0	58·3	,, ,, W.
,, 9	,,	53·0	58·3	,, ,, S.
,, 10	,,	52·4	57·9	Thunder Showers S.W.
,, 11	,,	52·3	58·0	,, ,, E.
,, 12	,,	53·7	57·9	Dull and Fine N.E.
,, 13	,,	54·2	57·3	,, ,, N.
,, 14	,,	53·0	57·1	Dull and Showery S.
,, 15	,,	57·0	57·0	,, ,, W.
,, 16	,,	56·3	57·0	,, ,, W.
,, 17	,,	56·4	57·0	Dull and Warm W.
,, 18	,,	58·3	57·0	,, ,, W.
,, 19	,,	57·8	57·0	Dull and Showery E.
,, 20	,,	56·9	57·1	Stormy, Wind, Showers S.W
,, 21	,,	55·2	56·5	Thunder Showers S.
,, 22	,,	51·4	56·3	Dull and Showery W.
,, 23	,,	50·2	56·0	Cold Wind & Showery W.
,, 24	,,	49·0	55·8	Thunder Showers W.
,, 25	,,	48·6	55·6	Dull and Showery W.
,, 26	,,	50·0	55·6	,, ,, Fine N.W.
,, 27	,,	53·6	55·5	Dull and Showery W.
,, 28	,,	54·0	55·3	,, ,, Fine W.
,, 29	,,	55·2	55·5	Fine and Warm W.
,, 30	,,	61·0	56·8	,, ,, W.
,, 31	,,	56·0	56·6	,, ,, E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
Sept. 1	9 a.m.	55·0	57·0	Close and Fine	E.
,, 2	,,	54·5	56·7	Dull and Cold	E.
,, 3	,,	56·2	56·4	Misty and Stormy	E.
,, 4	,,	55·4	56·4	Dull, but Fine	E.
,, 5	,,	54·1	56·4	Fine and Warm	E.
,, 6	,,	56·0	57·0	,, ,,	E.
,, 7	,,	54·3	56·8	,, ,,	E.
,, 8	,,	56·1	57·0	,, ,,	E.
,, 9	,,	57·3	56·9	Close and Fine	S.W.
,, 10	,,	58·6	57·3	,, ,,	S.
,, 11	,,	60·4	57·8	Close and Dull	S.
,, 12	,,	59·8	58·0	Misty and Fine	W.
,, 13	,,	57·0	58·1	,, ,,	W.
,, 14	,,	51·6	57·5	Dull and Fine	E.
,, 15	,,	50·2	57·1	,, ,,	E.
,, 16	,,	56·5	57·0	Fine and Warm	S.E.
,, 17	,,	54·3	56·9	,, ,,	S.
,, 18	,,	51·6	56·5	Frosty and Fine	S.
,, 19	,,	48·8	55·7	Cold and Stormy	S.W.
,, 20	,,	45·3	55·0	,, ,,	W.
,, 21	,,	41·0	54·1	Frosty and Stormy	W.
,, 22	,,	45·9	54·0	Fine and Cold	W.
,, 23	,,	42·0	53·5	Frosty and Cold	S.E.
,, 24	,,	45·6	52·9	Misty ,,	N.E.
,, 25	,,	41·2	52·9	Frosty ,,	W.
,, 26	,,	44·6	51·7	,, and Rain	W.
,, 27	,,	55·5	51·5	Dull and Stormy	W.
,, 28	,,	48·8	51·8	,, Cold	W.
,, 29	,,	46·8	51·3	,, ,,	N.
,, 30	,,	47·6	51·0	,, ,,	N.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
Oct. 1	9 a.m.	45·6	50·7	Cold and Stormy	N.
,, 2	,,	48·3	50·5	,, ,, Fine	N.E.
,, 3	,,	45·8	50·3	Frosty and Stormy	S.
,, 4	,,	45·5	50·1	,, ,, Fine	E.
,, 5	,,	44·0	49·8	Dull and Stormy	S.E.
,, 6	,,	46·0	50·0	,, ,, Cold	S.W.
,, 7	,,	46·6	49·9	Rough and Stormy	S.W.
,, 8	,,	41·4	49·1	Cold and Stormy	S.
,, 9	,,	40·6	48·5	Cold, but Fine	W.
,, 10	,,	41·1	48·2	,, ,,	W.
,, 11	,,	45·9	48·2	Frosty, but Fine	W.
,, 12	,,	44·0	48·0	Misty and Stormy	S.E.
,, 13	,,	46·1	48·0	,, Fine	W.
,, 14	,,	41·9	47·9	,, ,,	W.
,, 15	,,	43·0	47·6	Frosty, but Rain	W.
,, 16	,,	48·2	47·6	Cold ,,	N.W.
,, 17	,,	44·5	47·7	Dull, but Fine	N.W.
,, 18	,,	46·7	47·6	,, ,,	S.E.
,, 19	,,	46·3	47·5	Cold and Stormy	E.
,, 20	,,	45·8	47·3	,, ,,	E.
,, 21	,,	45·0	47·1	Misty and Stormy	E.
,, 22	,,	45·5	47·0	Cold ,,	E.
,, 23	,,	45·0	47·0	,, ,,	E.
,, 24	,,	43·0	46·5	,, ,,	N.E.
,, 25	,,	40·5	45·9	,, ,,	N.E.
,, 26	,,	39·6	45·1	,, ,,	N.E.
,, 27	,,	40·0	45·0	,, ,,	N.E.
,, 28	,,	43·2	44·6	,, ,,	N.E.
,, 29	,,	45·5	44·6	Misty, but Fine	S.W.
,, 30	,,	46·3	44·7	Dull and Stormy	S.
,, 31	,,	41·2	44·6	Cold ,,	W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
Nov. 1	9 a.m.	46·0	44·5	Cold and Stormy	S.
,, 2	,,	39·2	44·2	,, ,,	W.
,, 3	,,	44·0	44·0	,, ,,	S.W.
,, 4	,,	43·8	44·0	Dull but Fine	W.
,, 5	,,	38·3	44·0	Frosty ,,	S.
,, 6	,,	44·7	44·0	Misty ,,	S.W.
,, 7	,,	46·0	44·0	Misty and Rain	W.
,, 8	,,	44·7	44·2	Dull ,,	W.
,, 9	,,	48·3	44·5	Dull but Fine	N.W.
,, 10	,,	48·4	44·9	,, ,,	N.W.
,, 11	,,	47·0	45·0	Thick Fog	N.W.
,, 12	,,	46·8	45·0	Close and Fine	S.W.
,, 13	,,	38·6	44·5	Frosty ,,	E.
,, 14	,,	42·0	44·6	Mild and Rain	S.W.
,, 15	,,	47·2	44·6	,, ,,	S.W.
,, 16	,,	49·0	44·8	Misty ,,	S.W.
,, 17	,,	43·0	44·9	Very Mild	S.W.
,, 18	,,	44·2	44·8	,, ,,	S.W.
,, 19	,,	45·8	44·8	,, ,,	W.
,, 20	,,	37·0	44·5	Dull and Cold	S.
,, 21	,,	37·0	44·1	,, ,,	S.
,, 22	,,	44·0	44·0	Dull and Stormy	S.
,, 23	,,	42·0	43·9	,, ,,	N.W.
,, 24	,,	42·0	44·1	,, ,,	W.
,, 25	,,	36·6	44·0	Snow Storms	N.W.
,, 26	,,	32·8	43·2	Snow Storms & Thunder	S.
,, 27	,,	26·5	42·0	Keen Frost	W.
,, 28	,,	25·0	40·8	,, ,,	N.
,, 29	,,	33·9	40·8	Thick Fog and Rain	S.
,, 30	,,	34·4	40·4	Keen Frost	S.W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1889. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Dec. 1	9 a.m.	34·4	40·4	Keen Frost S.W
,, 2	,,	30·5	40·0	,, ,, S.W.
,, 3	,,	31·2	39·4	,, ,, E.
,, 4	,,	31·0	38·6	,, ,, E.
,, 5	,,	32·2	38·4	,, ,, E.
,, 6	,,	32·9	38·0	,, ,, N.E.
,, 7	,,	33·3	37·7	Keen Frost and Snow S.
,, 8	,,	32·0	37·5	,, ,, Dull S.
,, 9	,,	45·0	37·0	Thick Fog and Rain S.W.
,, 10	,,	38·1	37·3	Dull and Stormy W.
,, 11	,,	29·4	37·1	Frosty ,, N.E.
,, 12	,,	30·3	36·5	,, Snow S.
,, 13	,,	37·0	37·0	Dull and Fine S.
,, 14	,,	28·6	36·2	Keen Frost W.
,, 15	,,	37·5	36·7	Thick Fog and Rain S.W.
,, 16	,,	42·0	37·6	,, ,, S.W.
,, 17	,,	47·6	38·0	,, ,, S.W.
,, 18	,,	45·0	38·8	Dull and Stormy W.
,, 19	,,	35·2	39·0	Frosty ,, W.
,, 20	,,	36·8	39·0	Snow ,, S.W.
,, 21	,,	35·0	38·5	,, ,, S.W.
,, 22	,,	44·9	38·4	Misty and Stormy W.
,, 23	,,	43·0	38·6	,, ,, W.
,, 24	,,	46·8	39·0	Rough and Stormy S.W.
,, 25	,,	38·2	39·0	Thick Fog and Fine W.
,, 26	,,	40·3	39·0	Dull and Fine S.W.
,, 27	,,	36·7	38·8	,, ,, E.
,, 28	,,	29·0	38·0	Keen Frost E.
,, 29	,,	30·4	37·1	,, ,, E.
,, 30	,,	22·2	36·4	,, ,, E.
,, 31	,,	31·4	35·2	,, ,, S.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
Jan. 1	9 a.m.	35·0	35·2	Dull and Cold	S.
,, 2	,,	29·5	35·2	,, ,,	S.
,, 3	,,	19·3	36·1	Keen Frost	N.E.
,, 4	,,	38·2	37·0	Dull and Stormy	S.
,, 5	,,	44·3	37·8	,, ,,	S.
,, 6	,,	41·9	38·0	,, ,,	W.
,, 7	,,	49·7	39·0	,, ,,	S.W.
,, 8	,,	44·2	39·6	,, ,,	S.
,, 9	,,	36·9	39·8	Cold ,,	W.
,, 10	,,	39·1	39·9	Misty ,,	W.
,, 11	,,	40·3	40·0	Cold and Fine	W.
,, 12	,,	41·2	40·1	,, ,,	W.
,, 13	,,	46·0	40·1	Misty and Stormy	S.W.
,, 14	,,	37·8	40·0	Frosty ,,	S.W.
,, 15	,,	37·5	40·0	,, ,,	S.W.
,, 16	,,	46·0	40·2	Dull and Fine	S.
,, 17	,,	44·9	40·7	Cold and Stormy	S.
,, 18	,,	39·6	40·7	,, ,,	S.
,, 19	,,	37·8	40·6	,, Fine	W.
,, 20	,,	32·0	40·2	Frosty and Snow	W.
,, 21	,,	31·8	39·5	Cold Rain and Snow	W.
,, 22	,,	33·9	38·8	,, ,,	N.
,, 23	,,	32·0	38·0	,, ,,	W.
,, 24	,,	33·0	37·8	Frosty, Rain	W.
,, 25	,,	49·2	38·2	Dull and Rain	W.
,, 26	,,	37·4	38·2	Strong Wind & Rain	W.
,, 27	,,	34·8	38·3	Cold, Snow	W.
,, 28	,,	32·9	37·6	,, ,,	N.E.
,, 29	,,	24·5	37·1	Keen Frost	E.
,, 30	,,	39·4	37·8	Dull and Rain	W.
,, 31	,,	44·3	38·0	Misty ,,	W.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
Feb. 1	9 a.m.	44·5	38·4	Misty and Stormy W.
,, 2	,,	37·6	38·7	Cold but Fine N.W.
,, 3	,,	37·3	38·7	Dull ,, S.W.
,, 4	,,	37·0	38·8	,, but Stormy W.
,, 5	,,	36·7	38·6	Cold but Fine N.E.
,, 6	,,	31·5	38·2	Keen frost N.E.
,, 7	,,	35·2	38·0	,, ,, N.E.
,, 8	,,	30·0	37·5	,, ,, E.
,, 9	,,	32·4	37·2	,, ,, E.
,, 10	,,	32·0	37·0	,, ,, E.
,, 11	,,	30·3	36·5	,, ,, E.
,, 12	,,	30·5	36·2	,, ,, E.
,, 13	,,	29·2	35·4	,, ,, E.
,, 14	,,	31·0	35·0	,, ,, E.
,, 15	,,	35·0	35·0	Snow and Rain N.E.
,, 16	,,	36·1	35·2	Cold but Fine S.W.
,, 17	,,	34 5	35 3	,, ,, E.
,, 18	,,	36·0	35·6	,, and Rough E.
,, 19	,,	34·4	35·4	,, ,, E.
,, 20	,,	31·3	35·2	,, and Snow E.
,, 21	,,	34·0	34·9	Dull but Fine S.E.
,, 22	,,	34·8	34·4	Frosty ,, E.
,, 23	,,	34·2	34·8	,, ,, E.
,, 24	,,	38·5	35·3	,, ,, N.E.
,, 25	,,	38·0	35·5	,, ,, E.
,, 26	,,	37·8	36·0	Cold and Snow Storms E.
,, 27	,,	32·0	35·9	,, Keen Frost N.E.
,, 28	,,	31·2	35·3	,, ,, N.E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
March 1	9 a.m.	32·6	34·5	Keen Frost and Snow	N.W.
,, 2	,,	26·5	34·1	,, ,, ,,	N.E.
,, 3	,,	26·0	33·8	,, ,, Cold	E.
,, 4	,,	25·5	33·0	,, ,, Rain	S.W.
,, 5	,,	33·1	34·0	,, ,, ,,	W.
,, 6	,,	42·0	35·2	Dull and Stormy	W.
,, 7	,,	43·0	35·9	,, ,,	W.
,, 8	,,	34·5	36·0	Frosty and Snow	S.W.
,, 9	,,	32·7	35·8	,, ,,	S.W.
,, 10	,,	42·4	36·0	Dull and Stormy	S.W.
,, 11	,,	44·3	37·2	,, but Fine	S.W.
,, 12	,,	45·8	37·8	,, ,,	S.W.
,, 13	,,	41·4	38·2	,, and Stormy	S.W.
,, 14	,,	40·0	38·5	,, ,,	S.W.
,, 15	,,	41·6	38·8	,, but Fine	S.W.
,, 16	,,	51·0	39·1	,, and Rain	S.E.
,, 17	,,	38·0	39·7	Cold and Stormy	S.W.
,, 18	,,	38·7	39·8	,, ,,	S.E.
,, 19	,,	36·5	39·6	,, Snow	S.E.
,, 20	,,	35·8	39·4	,, ,,	W.
,, 21	,,	36·0	39·3	Dull ,,	W.
,, 22	,,	37·5	38·9	,, ,,	W.
,, 23	,,	42·0	39·3	,, Rain	W.
,, 24	,,	39·3	39·1	,, ,,	S.E.
,, 25	,,	40·6	39·5	Cold and Stormy	S.E.
,, 26	,,	43·0	40·1	Dull ,,	W.
,, 27	,,	47·8	40·5	,, ,,	S.W.
,, 28	,,	48·1	41·0	,, but Fine	S.W.
,, 29	,,	43·0	41·4	,, ,,	W.
,, 30	,,	45·4	41·9	Clear and Fine	W.
,, 31	,,	40·4	41·8	Frosty ,,	E.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.
		Air.	Water.	
April 1	9 a.m.	42·3	41·6	Frosty and Fine S.E.
,, 2	,,	45·1	41·6	,, ,, E.
,, 3	,,	44·7	41·8	,, ,, E.
,, 4	,,	45·0	41·9	,, ,, E.
,, 5	,,	41·8	42·3	,, ,, E.
,, 6	,,	43·2	42·6	Dull and Rain W.
,, 7	,,	40·6	43·0	Cold and Showery W.
,, 8	,,	38·5	42·8	,, ,, N.W.
,, 9	,,	37·9	42·8	Cold but Fine N.
,, 10	,,	37·3	42·7	Frosty ,, N.E.
,, 11	,,	40·1	42·9	,, ,, N.
,, 12	,,	38·6	42·8	Frosty and Snow N.E.
,, 13	,,	36·8	42·6	Dull ,, ,, E.
,, 14	,,	37·0	42·0	Very Rough and Cold E.
,, 15	,,	38·6	41·9	,, ,, E.
,, 16	,,	40·3	41·8	,, ,, E.
,, 17	,,	41·2	41·8	,, ,, E.
,, 18	,,	38·1	41·5	,, ,, E.
,, 19	,,	38·5	41·3	,, ,, E.
,, 20	,,	41·0	41·9	Dull but Fine S.
,, 21	,,	46·6	41·9	Dull and Showery S.
,, 22	,,	47·0	42·0	,, ,, W.
,, 23	,,	45·2	42·4	Cold ,, W.
,, 24	,,	43·3	42·8	,, ,, W.
,, 25	,,	40·3	42 8	,, ,, N.W.
,, 26	,,	41·9	42·9	Cold but Fine N.E.
,, 27	,,	44·6	42·9	Dull ,, N.W.
,, 28	,,	40·3	43·2	,, ,, N.E.
,, 29	,,	49·5	43·9	,, ,, S.
,, 30	,,	53·8	45·3	Fine and Warm S.

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OLDHAM CORPORATION WATERWORKS.

OBSERVATIONS, DENSHAW.—*Continued.*

1890. Date.	Hour.	Temperature.		Remarks on Weather, &c.	
		Air.	Water.		
May 1	9 a.m.	44·0	44·7	Cold, but Fine	E.
,, 2	,,	49·6	45·3	Fine and Warm	E.
,, 3	,,	51·3	46·4	,, ,,	S.E.
,, 4	,,	52·6	47·6	,, ,,	E.
,, 5	,,	46·4	47·7	Misty and Rain	E.
,, 6	,,	53·2	48·4	Thunder and Warm	E.
,, 7	,,	50·1	48·6	Close and Warm	S.E.
,, 8	,,	46·5	48·3	Misty and Rain	E.
,, 9	,,	45·4	48·0	Misty and Wild	E.
,, 10	,,	46·0	48·0	Misty and Showery	E.
,, 11	,,	47·3	48·3	Very Wet	N.W.
,, 12	,,	56·0	49·6	Thunder and Rain	W.
,, 13	,,	48·9	50·0	Thunder, but Fine	W.
,, 14	,,	48·6	49·8	,, ,,	W.
,, 15	,,	46·5	49·3	Cold and Stormy	S.W.
,, 16	,,	45·4	48·9	Very Wet	S.
,, 17	,,	50·0	49·2	Dull and Stormy	S.
,, 18	,,	50·0	49·2	Fine and Warm	S.
,, 19	,,	54·2	49·8	Dull and Rain	E.
,, 22	,,	54·9	50·5	Cold, but Fine	S.E.
,, 21	,,	51·8	50·6	,, ,,	S.
,, 22	,,	58·6	51·2	Fine and Warm	S.
,, 23	,,	61·4	52·8	,, ,,	E.
,, 24	,,	57·0	53·2	Fine, but Wild	E.
,, 25	,,	52·7	52·9	,, ,,	E.
,, 26	,,	47·0	52·3	,, ,,	E.
,, 27	,,	48·3	52·8	Fine and Warm	E.
,, 28	,,	51·3	53·0	,, ,,	E.
,, 29	,,	52·0	53·2	Dull and Rain	W.
,, 30	,,	51·6	53·9	Cold, but Fine	W.
,, 31	,,	51·0	54·1	,, ,,	W.

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NITROGEN GAS IN STRINESDALE TUNNEL.

By Mr. William Watts, F.G.S.

At an early meeting of the Society during the present session I reported an outburst of nitrogen gas from the fissures of a white rock in Strinesdale Tunnel. This gas had seriously interfered with the health of the miners, and obstructed free combustion of candle light. It was free from smell and did not make the men breathe heavily as an atmosphere charged with carbonic acid gas from old colliery workings.

The gas escaped very freely at times from openings in the rocky floor, sides, and roof, and, in some instances, was sufficiently strong to extinguish a candle blaze 18 inches away from the fissure. It was not simply a blowing out by the current or force of the escaping gas, but an instantaneous snuffing out, leaving no doubt in my mind that it contained very little oxygen. On some occasions the gas ceased flowing, and a candle light could be held in the fissure with impunity; whilst on other occasions the air of the heading was drawn, or sucked in, thus reversing the current which seemed to me, and others who witnessed it, a strange phenomenon and inexplicable, except on the hypothesis that the clefts in the rock communicated with the surface of the ground or some disused colliery workings which exist in the neighbourhood.*

Some of the fissures contained iron-pyrites in addition to crystals of felspar and quartz, but mainly the former. The rock is fine in texture and lies in beds of about 18 inches to 2 feet in thickness. It disintegrates on exposure to the

* Mr. Le Neve Foster, B.A., F.G.S., H.M. Inspector of Mines, North Wales, informs me that there is a waterfall at Buxton which gives off nitrogen gas.

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atmosphere, and, therefore, is not a suitable building stone. Silica seems scarce in it.

The nitrogen blowers to which I have referred continued in a modified form for months. Indeed we are not entirely rid of them to-day, but their force is greatly diminished, although the tunnel invert is about 400 feet below the surface of the ground.

On some few occasions, when the atmosphere outside the tunnel was heavy, or the wind blowing into the heading, the miners were dazed when leaving their work, and two of them had their legs semi-paralysed for a brief period, but no other results followed.

Very efficient ventilation, and stopping the openings with clay paste, were requisite to restore the air in the heading to a breathable condition and fit for the men to work in.

When I mentioned this matter to the Society, some months ago, the members present doubted my conclusions, and requested me to have the gas analysed. I have done so, and Mr. Frank Pullinger, B.A., F.C.S., informs me that it contains—

Nitrogen	92 volumes.
Oxygen	8 „
Carbonic acid	A trace.

The dizzy effect produced on the men, Mr. Pullinger says, was due to the absence of a sufficiency of oxygen.

For his kindness, and the ready way Mr. Pullinger has helped me, I return him my hearty thanks.

Mr. Dickinson moved a vote of thanks to Mr. Watts for his paper.

Mr. Watts, replying to a question, said that, in the tunnel, they had passed through three of the lower coal seams, and doubtless they were in close proximity to some old workings. But what astonished him most was the

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fact that 1,039 yards in, and directly under the hill where there was no coal above or below, there occurred from time to time these inrushes of nitrogen.

The PRESIDENT asked if it was possible the air taken to be analysed could have been that resulting from the use of an explosive, rather than what had issued from the strata?

Mr. WATTS: Oh dear, no! Permit me to explain the mode by which the gas was collected. I got the fissure sealed up with clay, and then inserted a small pipe the end of which was inserted into a bottle of water: this water was gradually poured out, and the gas rushed in, and before the whole of the water had disappeared it was carefully sealed up, so that there was no possibility of the fumes from the heading getting into the five bottles which Mr. Pullinger and his brother were kind enough to collect and analyse for me.

In answer to another question, Mr. WATTS said the whole thing was to him a phenomenon, and he had brought it before the Society with a view, if possible, to elicit some explanation. He thought some of the members would be better able to judge of the matter than he was himself.

Mr. SAINT asked if the gas in question was readily diffused throughout or lay near the floor.

Mr. WATTS: Long before we detected the gas coming out of the fissures in the roof we heard bubblings in the bottom of the floor, or invert, as we call it. We have a small amount of water rushing in at the floor, and in several places we heard this bubbling; but I came to the conclusion that it was the inrush of the water and not the nitrogen gas, which we subsequently found to be the case. Further, as you are aware, the miners when they are drilling often put their candle as near to the hole as possible: on some occasions the outrush from the bore holes in this tunnel has been sufficient to extinguish the candle placed near the bore hole.

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Mr. GRUNDY: Have you taken any special means to determine whether there is any considerable proportion of carbonic acid gas present?

Mr. WATTS: There is a trace, as indicated in the paper. Mr. Pullinger, I may add, came twice, and was greatly interested in this matter. I asked him to be as careful as he possibly could so that his analysis would bear criticism before this meeting; and I think we may take that analysis as having been made with all the care that was possible also to get the gas as it came from the fissure perfectly pure.

Mr. TONGE: At the point where the nitrogen gas has been issuing, is it possible that there may be crevices in the rock above bringing the gas from some nitrogenous matter?

Mr. WATTS: Its first appearance was at a distance of 729 yards from the face; we are now 1,038 yards, and it is again troubling us, though we have not so much of it as we had at the first. At 1,038 yards we are a little over 400 feet below the surface of the ground. I have already explained that the Lower Coal Measures do not crop out above. Indeed, immediately underneath the High Moor Rock, which is termed the Woodhead Hill Rock, there is no coal of importance. At 700 yards we should be probably 250 feet below the surface of the ground, there we are more in the immediate neighbourhood of the outcrop of the Mountain Mine, through which we have cut.

The PRESIDENT asked if any other gentleman had met with a similar experience to Mr. Watts.

Mr. WILD: I do not know that I have met with strange gas which would put out a lamp, but in an old tunnel we met with what has been called "white damp." The atmosphere affected breathing very much, and the chest also, causing very severe aching pains; but the candle burnt brightly to the face. Anyone breathing the atmosphere for an hour or two would feel the effects for days afterwards.

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What the gas was, which produced those effects we never ascertained: it was locally known as white damp. I had previously supposed white damp to arise from the blasting process. The tunnel was a single one, and was arched to within four feet of the face, and had been standing some years.

Mr. WATTS: In the Strinesdale tunnel the instant, almost, that we put the candle to the fissure from which gas was escaping it went out.

The PRESIDENT: I do not think you told us whether this gas sought the bottom or escaped near the roof—whether it seemed to be heavier or lighter than the air in the place.

Mr. WATTS: I did not make any tests with reference to that. But it escaped more at the sides and out of the holes which the men made with their drills when they hit upon a joint.

Mr. BOOLE said it had occurred to him that there might be an explanation of this phenomenon. Supposing the gas were formed originally from atmospheric air, by the action of the air on coal, they knew that under certain conditions the oxygen of the air would enter into combination with the carbon of the coal to form carbonic acid gas; and he believed this took place in old workings very frequently, and also in seams which were near the outcrop. In such a case, if the air was deprived of its oxygen by the coal, the nitrogen of the air must remain; and Mr. Grundy's remark as to the solubility of carbonic acid gas might account for the nitrogen being left behind—the carbonic acid gas being absorbed by the water in the strata.

Mr. WATTS observed that he thought this might be a very feasible explanation. He added, in reply to an observation from Mr. Grundy, that the gas was not rushing out now quite in such volume as formerly. They had to start the "blower" on a Sunday evening—12 hours or so before the

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men went in. If they failed to do that the men could not commence work so soon on the Monday morning. The ventilation must be very efficient, notwithstanding that they had the tunnel lined with brick for about 750 yards out of the 1,000. They had followed up as soon as they could with the brick lining, in order to exclude the nitrogen as well as to expedite their work.

Mr. WILD suggested that there might be a bed of iron pyrites in the neighbourhood, chemical action upon which might produce the phenomena to which Mr. Watts had called attention, as it is known that there are hundreds of tons left in the disused mines of the neighbourhood which in decomposition would absorb much oxygen.

Mr. WATTS said that, in some joints, they had found abundance of iron pyrites, the presence of which caused quite a sensation in the neighbouring village. The inhabitants, hearing that gold had been found, went and gathered great quantities.

Professor DAWKINS said he thought the explanation they had had from a member was very probably the correct one. He thanked the gentleman who had spoken for having given them such a simple view of the matter.

THE CARBONITE SYNDICATE EXPLOSIVES.

BY MR. WILLIAM WATTS, F.G.S.

This Company wrote to the Secretaries of the Manchester Geological Society some time ago to ask if the Council would undertake to test their new explosives. In reply, it was explained that the Society, as a body, was not an experimenting one, but if individual members wished they had the option of obliging the Company. Accordingly I communicated with Mr. Larsen, one of the managing

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directors, who kindly furnished me with 1¼ cwt. of his explosives, and came over to see a few shots fired in Strinesdale Tunnel.

The explosives are of two kinds, viz., carbonite and stonite. Carbonite is a mealy brown substance, not unlike disintegrated old red sandstone in appearance. Stonite is a dark pasty substance, somewhat incoherent at a temperature of about 70°, but hard at a low temperature. It is a more powerful explosive than carbonite, and does its work more efficiently, but the quantity we used did not enable us to make decided tests. Both compounds give off gaseous fumes on explosion fully equal to tonite, but much less dense than blasting powder. Carbonite, on explosion, leaves a deeper socket in the shot hole than stonite, a proof that its combustion is less efficient and energy less tremendous. I am not able, however, to estimate the pressure of explosives except by results, and my observations must be taken for what they are worth. It does not follow that a powerful explosive is the best in all classes of rocks. It must be judged by the effects produced in the strata dealt with. The relative strength of the common explosive agents, as far as tunnel driving is concerned, must, in my opinion, be measured by their commercial results, and not as shattering agents.

Carbonite occupies an intermediate place between tonite and blasting powder, and may be found useful in fiery mines. Such, however, are the economical uses I have formed of it.

Neither compound is made up in a form convenient for ready use. Probably the low temperature at which the mixtures harden prevent the cartridges being made up similar to tonite. A mechanical mixture requiring to be kept at a given temperature does not find favour with miners, and to carry it about with them for warmth adds danger to an inconvenience. A warm water bath is a

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simple expedient for airing the cartridges, but it requires attention and is often at the wrong place when wanted.

Tonite, stonite, and carbonite are detonated in the same manner, but the former comes ready pierced for the "cap." The two latter require piercing, which the miners do not like. Obviously some little delay takes place in attaching the detonators to the explosive substance which it would be better to avoid, and if the cartridges could be made up in the form of tonite "pills" it would save time and bring them more into favour.

With regard to tamping, the treatment is the same in the three mixtures.

The thanks of the meeting were voted to Mr. Watts for his interesting communications.

NOTES ON THE UPPER PERMIANS, &c., AT FALLOWFIELD, LATELY LAID OPEN.

By Mr. Charles Roeder.

PART I.

In the latter part of April of this year the excavations now in progress at Fallowfield, between Ladybarn Lane and Slade Lane, were carried to a level sufficiently deep to expose and lay open the edges of the *Upper Permian Series*, and some members of the Upper Coal Measures, namely, the *Ardwick (Spirorbis) Limestones*. These discoveries in that direction came, of course, not as a novelty, for their existence at various adjacent points had been demonstrated some six years ago, in connection with sewerage schemes which necessitated a series of shaft sinkings along parts of Burnage Lane and Mauldeth Road. At the former points the Spirorbis banks were struck upon, while at the

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latter, the Upper Permian beds were reached. Further detailed sections and investigations were promised at the time, but the matter remained a desideratum, and consequently our knowledge with respect to the extent and relationship of the two formations in these parts of the South-East of Manchester was not particularly increased. Under these circumstances the course of the present excavations has been followed with unmitigated interest by all those who had become aware of their out-crop at a point situate considerably to the west of a line drawn on the older Geological district map, the boundaries of which in this respect were merely preliminary and of a tentative kind. As one who has been able uninterruptedly to study the progress of the excavations, I may be permitted to address you for a short time for the purpose of bringing under your notice some of the features of particular parts of the section which call for remarks and deserve notice.

Starting from the railway bridge now constructing at Ladybarn Lane with Mellor's Farm at the north side, we shall follow the line in its easterly direction, and arriving at a point just opposite the second farm, belonging to Mr. Grundy, we notice on the northern embankment the appearance in the Triassic beds of a series of intercalated red and white marl, 12 to 13 inches thick, offering a fine illustration of displacement in consequence of the occurrence of a fault. The result is a down-throw to the west of about 23 inches; the marls assume a dip of 5°, rise again in a curve, and fall away again at about 10° to the west, while the up-throw side maintains a slope of about 8°. The fault hades at an angle of 80°, running N.N.E. magnetic, and the two contiguous surfaces are found quite smooth and striated. The slipped ends of the marl beds taper away, and have undergone lamination and shaving, and constitute true slickensides. Leaving this point, and about 280 yards further down, the Triassic rocks which at Ladybarn Lane

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bridge reached a height of about 18 feet fall gradually away, and lean against the low out-cropping truncated edges of the Permian Marls. The new railway affords an exceptional opportunity of observing the contour lines of the New Red Sandstone from Houghend Clough onwards. In the cloughs the Boulder clay is sinking considerably, and concealed by stretches of white bleached forest sand; then a little further to the east the rock rises again to the surface, disappearing again under the thickening boulder clay, some distance before we reach the high road at Fallowfield; when it rises again to a maximum point at Ladybarn Lane bridge and disappears at the junction with the Permian Marls, where in its turn the boulder clay grows in thickness (*i.e.*, 14 feet), maintaining this average within a few feet until it reaches the east side of Burnage Lane railway bridge, where it is found to assume a thickness of 24 feet. The contour lines we meet on traversing the terrain described seem to indicate that we have to do with very long-stretched, gentle curves and undulations—hill and dale systems on a small continuous scale—and that there cannot have been any great violence of movement or extremes of denudations so far as the Triassic rocks are concerned, when glacial conditions invaded the area which is under our immediate consideration.

Reverting again to the junction of the Upper New Sandstone and the Permians, which have here been cut off by a fault, I have thought it the most convenient course to adopt to elucidate matters, to prepare a series of photos. *(see diagrams)*, which have been kindly taken by Mr. M. W. Thompstone. The only source of regret I feel in placing the same before you is the circumstance that the set is not to be considered complete. Parts of the section have at no time been sufficiently exposed, other important ones are masked and filled with boulder clay, and the opposite south embankment, which might have helped considerably in unravelling the

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much contorted and faulted structure of the Permian strata met with, was not accessible to us when I visited the section, together with Mr. Stirrup and Mr. Thompstone; being so obliterated by continual rainwash that it was perfectly useless to attempt taking any plates on that side. But with all these drawbacks I trust that the coloured views exhibited, accompanied by all the essential specimens required for gaining a clear conception of the lithological nature of the various beds, will be enough to serve for the description and observations which I shall have to make in connection with the subject. Beginning, therefore, with the New (Upper) Red Sandstone, which, it may be observed, assumes along the line a dip varying between 10 to 15°, and presenting many instances of false bedding and other smaller or greater faults and cracks, of which more later on, we see on looking at the coloured section that the Triassic beds rest on the slopes of the Permian marls, which are cut off to the west by a fault, and thrown down on that side to a depth and extent which we have, at present, no means to ascertain. The remaining slight overlap of the New Red Sandstone extends about 23 inches, and at the point of the sudden descent of the marls the thickness of the overlying younger formation measures 27 inches. I have particularly examined the faulted junction, and it appears that the marls in consequence of the downslip have assumed a scaly, laminated composition, perfectly slickensided, and become so tenacious a mass as to form a regular paste of a motley colour, due to the intimate incorporation with the New Red Sandstone, which at the fault has the appearance of a white, thick-coated plaster. I have looked at this place for chance traces of Permian debris or fragments as possibly imbedded in the Trias, but my search has been unsuccessful; however, such indications may exist further to the west at deeper levels.

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I must now dedicate a few minutes to the examination of the extent of the Marls, Sandstone beds, and Limestones. We find in descending order the following *horizontal* relations:—

Feet.	
36	Marls, comprising various thin limestone bands, calcareous sandstone, and indurated clay.
6	Compact, whitish-green limestone.
6	Rather micaceous sandstone and compact crystalline sandstone banks.
36	Marls.
15	More or less weathered sandstone banks.
27	Boulder clay, filling apparently a hollow and pointing to the existence of another fault.
51	Ditto, underlaid by a reddish, specifically permian-derived boulder clay.
183	

This would comprise and constitute the Upper Permian series.

These are succeeded by the Lower Permian group, viz.:—

Feet.	
34	White and red, very compact calcareous conglomerates.
45	Red, coarse-grained, well-rounded, disintegrated sandstone, which seems to have undergone the action of water.
1446	Soft micaceous sandstone, very regularly deposited, and showing throughout its whole length a constant dip of about 20° to about N.N.W. magnetic.
1708	Total.

The Lower Permian Sandstone group is followed by the purple marls west of Burnage Lane Bridge *(see diagram)*, which here are overlapped by the former. The dip of these

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purple marls at that point is concordant with the above, and shows no break; they are apparently quite conformable.

I have now to speak of the thickness of the Upper Permian series. As indicated above, the horizontal extent is 183 feet, but we are left without reliable means of arriving at their thickness, as they are too plicated and contorted to offer a safe basis to go upon; any speculation is therefore useless.

The lower conglomerates and sandstones do not offer the same difficulty, and may be put down as being of about 500 feet thick.

After this short outline I must return again to the photographic section, and propose now to give some details of various and clearly revealed deposits. I have bracketed the bands and beds I wish to describe, and which are in descending order as follows:—

Inches.

3·5 Calcareous sandstone with dendrolitic formations on the surface, micaceous, easily splitting and powdery to the touch; imbedded in it we find occasionally small oval ferruginous bodies. We notice in it the occurrence of fine, small, well-preserved specimens of *Schizodus*; their existence in this sandstone has not been registered by the older observers of the local Permians, and as they occur rather rarely, their presence, no doubt, has been overlooked.

0·6 Red laminated clay without fossils.

0·4 Chocolate coloured and greenish-white shell marl, the shells mostly flattened and almost indistinct; they are not scattered pell-mell, but are deposited in regular layers, lamina on lamina, and on exposure crumble away in small lenticular masses. This shell marl is principally made up of shoals of *Gervillia*;

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if we wash and sift the undissolved residuum we find in it great numbers of very small *Turbos* and minute, complete *Gervillias*, and, what is rather interesting, large rounded quartz grains, of pin-head size, which no doubt drifted into it from the more distant lower sandstone deposits.

8·0 Red clay with thin shell partings between them, but too obscured at the time they were examined to make out details.

1·0 Greenish-white limestone band, broken up into fragments in consequence of the complete plication the band has undergone. We meet with many concretions. The leading fossil contained in it is *Schizodus*, mostly flattened and broken into many pieces and traversed by calcareous fissures, the shells often 1·8 inches high. They are the largest specimens of the *Schizodus* group, and the band seems wholly made up of them, forming a kind of breccia. At the bottom it passes into a reddish limestone, composed of innumerable swarms of *Gervillia*, which are covered with a ferruginous skin. The shells are overrun with annelida of the *Vermilia obscura* type.

16·0 Red clay, too obscured to make out.

1·8 Indurated red clay; the upper surface contains complete and fine specimens of *Gervillia*, but few in number, often in their living position, the striæ quite distinct, as well as the dorsal structure. They are also coated with *Vermilia;* the colour of the shell substance is of deep amber.

1·8 Purple or chocolate shell marl.

1·5 Red, massive clay without fossils.

0·8 Ferruginous deep-red clay, concretionary, unfossiliferous.

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6·7 Pure, red clay, of conchoid fracture, on exposure breaks away in irregular cracks, but later on hardens; exposed to the rain it splits into fine lamellæ, crumbling away in concentric layers. It is devoid of mollusca, and seems to be a quiet deposit which at regularly recurring periods covered the living shells. It is only quite exceptionally that we here and there in the upper parts meet with some sporadic small *Schizodus*, as mere specks, but otherwise they are sterile.

0·6 Shell clay.

7·8 Pure red unfossiliferous clay, as described.

0·5 Shell clay parting.

6·0 Red clay without fossils.

2·2 Greenish, shelly calcareous clay, of a lumpy and knobby constitution; on breaking the rounded masses, we find the inside hollow and filled with small calcite crystals.

1·0 Red clay.

0·5 Green, pasty calcareous mass, fossiliferous.

3·5 Red clay, when disengaged *in sitû*, it presents a cubic arrangement, running in long horizontal columns, 0·5-0·6 in. wide; these very regular slices adhere to the underlying white calcareous paste, as if impressed in it, while the white mass is squeezed up between the separate columns. We observe that these long columns always run in the same direction, their long axis placed North and South.

0·5 Green band, fossiliferous.

0·5 Hard red clay, of bandy structure, jasper-like, difficult to break. Exposure will break it up into fine lamellæ.

1·5 Green band, fossiliferous.

1·0 Red, indurated clay, as before.

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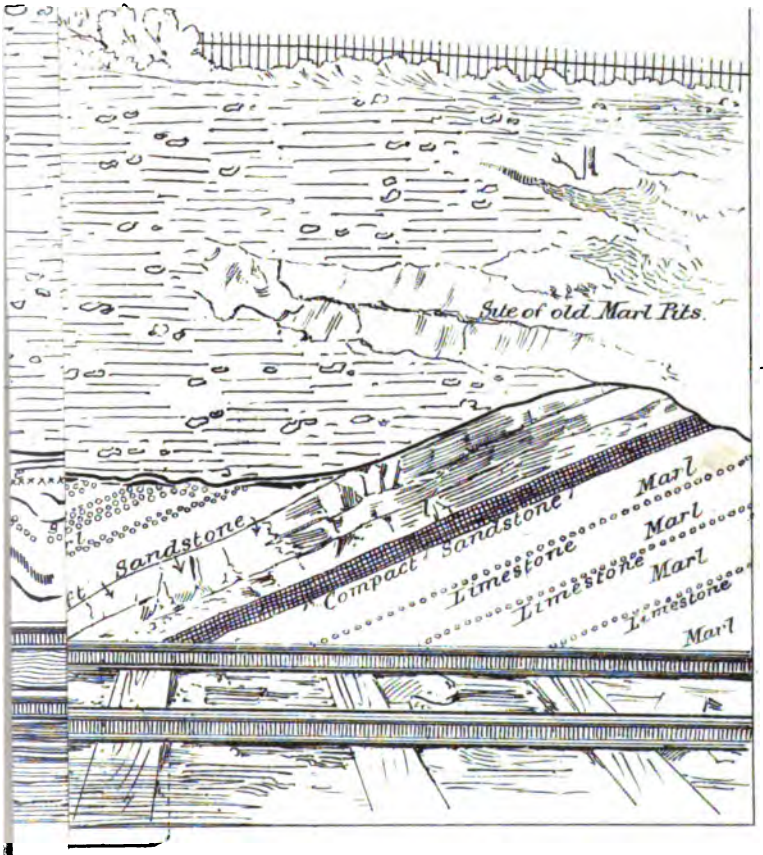
To illustrate Mr. Roeder's paper.



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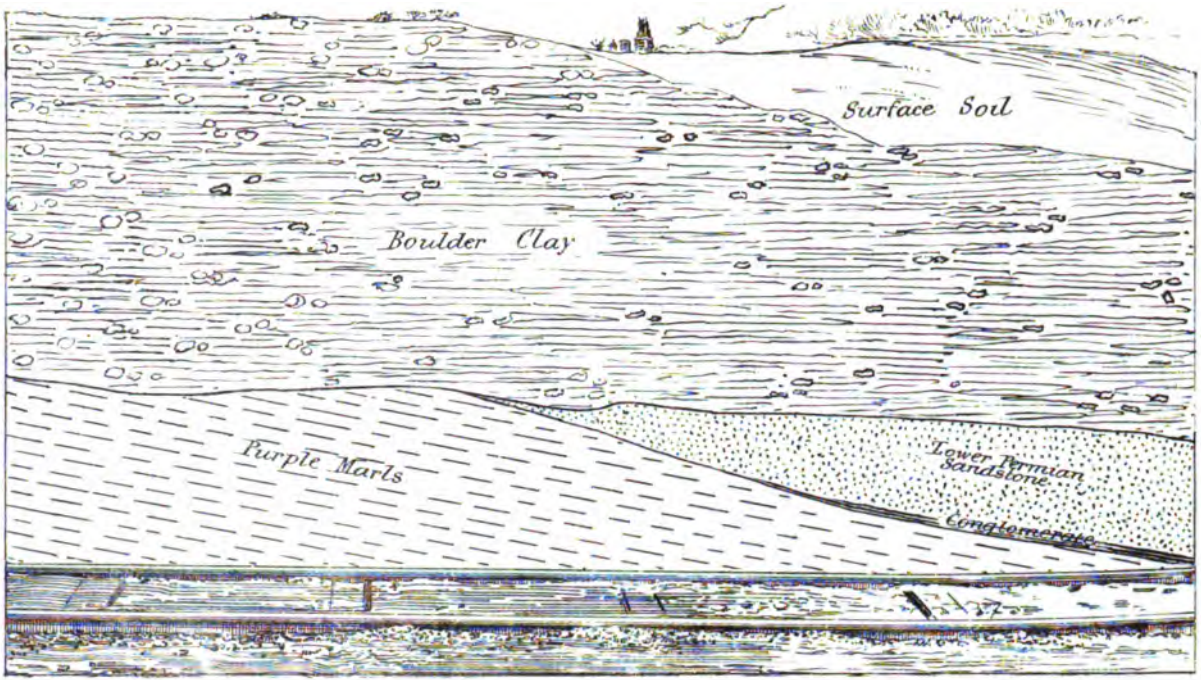
Burnage Lane.

about 10 yards West of Burnage Lane Railway Bridge (now in course of construction)



Junction of Upper Coal Measures & Lower Permian Sandstone

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To illustrate Mr Roeder's paper.

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6·0 Compact limestone, greenish-white, on longer exposure turning yellow; often marked with ferruginous patches and nests. It contains quantitatively the greatest number of shells. We find here *Schizodus, Pleurophorus, Turbo, Gervillia? Edmondia, Vermilia;* besides, in certain regions, masses of black bodies, sometimes globular, vermiform, or tubular, which seem to be of coprolitic origin, and may be owing to the mollusca. There also occur traces of *Filograna Permiana,* while of the brachiopods, as *Strophalosia,* no indication whatever can be found. This limestone, on exposure, peels away, and is often traversed by a series of fracture lines which in time have been filled with calcite. The colour varies, often greenish, or dirty white, dark red; the shells on the surface are often very distinct, and of yellowish-brown appearance, the striæ not always present; nor do we find complete bivalves, or only rarely so. The total accumulation consists of debris, all mixed up; at the higher points the mass becomes loose and rotten, and can be easily dug out. Often this limestone passes into concretionary, honey-combed structures, or masses of calcitic plates.

2·0 Red clay.

2·5 Greenish limestone.

1·5 Red clay.

0·2 Shell parting.

10·0 Soft, reddish sandstone.

6·0 Fine-grained, crystalline sandstone.

Total, 97·9 inches—so that within a range of 98 inches (and it is to be remarked that I only speak of a fraction of the numerous beds of which the Upper Permians are made

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up here), we have within the insignificant space alone 31 different individual deposits before us, or a change, in average, at every three inches, leaving out of calculation these undefined clays spoken of, which, as I shall show further on, are, at every few inches, parted by a series of thin shell-bearing layers.

The last two deposits of sandstone deserve a special word, as they are of special interest. I mean the

10·0 inch soft sandstone.
6·0 ,, compact sandstone.

These are marked on the right side of the section in yellow; the upper part (10 inches) is of a soft texture, micaceous, light red, the layers sometimes curved, of mottled colour, and the surface puckered, at times iron-stained. They also bear impressions of worm-tracks and footprints—all indications of shallow shore-water and sub-ærial exposure. We further find indistinct traces of plants, in the shape of leaves, and a small cylindrical stem, one inch long, in appearance like a *Calamites* species. Next we come upon fine ripple markings, with ridges from quarter to half-inch, and in the sandstone banks further away to the east, where the currents seem to have been rather troubled, the surface offers an irregular mammillated configuration, full of protuberances, often one inch across, probably pointing to a shore where the tide on falling ran in different directions amongst the channels. Below these deposits we have six inches of compact, very heavy crystalline sandstones, which had to be quarried and cut out in long slabs. The upper surface is frequently covered with sun cracks. The bottom, however, which it must not be forgotten represents the top part on the large slab placed before you, shows a regular system of ridges varying from 0·5 to 1·5 inches wide, and covered with immense agglomerations of extremely well preserved shells, scattered broadcast over the whole surface. These blocks when raised from their natural position

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are found imbedded in a granular and highly ferruginous mass. The counterpart, which, on the other hand, rests on a red clay, forms a kind of cake or incrustation, also containing fossils, but to a lesser degree, and has when fresh a metallic greyish blue or bronzy colour. On the application of the water tap and brush, to remove the adhesive clayey matter, the slabs, as you observe, appear to abound in shells, of which *Gervillia*, *Turbo*, *Rissoa*, *Natica*, preponderate, while *Pleurophorus*, *Schizodus* are of rarer occurrence. Most of the shells, both their outer and inner sides, are grown over with the ever-present *Vermilia*. The striæ and sculpture are exquisitely exhibited, also the dorsal parts and hinges, &c. The shell substance itself is almost transparent, and very delicate, and displays a bronzy shimmer. These long ridges recur in such a regular succession that we cannot attribute this fact to mere accident. In order to obtain some answer I carefully removed these blocks *in situ*, and examined the proper bearings of the troughs, which, I found, proceeded in a direction about N. by W. magnetic, and run in parallel order, extending to indefinite length. Sometimes they were joined by oblique cross bars, and the troughs (respectively ridges) varied in width. The slabs rested on a ferruginous crusty paste, half-inch thick, forming in fact the substance impacted on the super-incumbent sandstone. This mass, in its turn, which sometimes gives rise to sub-globular and conical structures, is composed of a thick shell-breccia, and has at its base a layer of chocolate or red coloured fossiliferous marl, followed by an irregularly fractured deposit of red clay, in which fossil remains are absent.

On reflection, there seems to my mind but little doubt, that we must regard these straight and rather rigid shell-ridges, impounded as they are on the inferior portion of the compact sandstone, once fine loose sand, as a demonstration of a beach overspread with a regular, well-preserved system

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of ripple-marks, and probably very nearly within the reach of the coast line of the Permian Sea, bounded at Burnage Lane (1,600 feet away from here) by the Upper Coal Measures with their bold and eroded limestone cliffs. Owing to the change of currents, the direction of the ripples would not always maintain their regular parallelism, but would intersect at various angles, and to this circumstance we must, I think, refer the frequent presence of oblique bars and minor ridges, while the greater or lesser interval between the various ridges may be due to the extinction of previous sets by the next tide. The currents, of course, in the present case, must have been in a direction W. by S. to E. by N.—that is, at *right angles* to the axis of the observed ridges. It is clear, if we take into consideration the manner in which the shell remains are thrown, in big shoals and heaps, strewn all over the Permian floor, and crowded and packed into each other, in all possible positions, that they can only represent a real sea-sweep—spolia marina—rolled and amassed at the mercy of the waves, as they thronged and lapped to and fro, and that this loose and dead freight, thus gathered up, became eventually engulfed in the deep ripple-troughs and cavities, to be finally covered, but *sufficiently quick* to prevent their fine sculpture from being abraded or injured by a long exposure, or by the action of tidal movements. We scarcely can expect to find these shell-ridges possessing the perfect sinous contours of ripple-markings we actually meet at the sea shore, as the filling up of the troughs with shell material must have obliterated their wavy lines and produced a more rigid appearance.

It seems also that the formation of extensive tracts of marshes may have possibly given rise to the ferruginous precipitations we meet with; they may be the product of the decomposition of vegetable life, and laid down either *in situ* from still waters or carried down by currents. We find these deposits,

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forming seams up to half-inch thick, not only at Fallowfield, where they occur interpolated between the marls at different levels, but also at such widely removed points as Reddish, Ardwick, Openshaw, Cheetwood, etc. At Fallowfield I have observed four such deposits, although there may be others which I may have passed. They are easily traced, especially after a wet day, when they are recognized by the ochraceous ooze trickling from them. Sometimes they rest on unfossiliferous clay, but more frequently on a greenish or mottled shell marl. They are particularly interesting, as we find here the finest and best preserved shells, as *Pleurophorus*, *Schizodus*, *Rissoa*, *Turbo*, etc., all exceptionally complete, and with their markings preserved. On washing and sifting this ochraceous or haematitic mass we are surprised to see that the greater part consists of the *detritus* of fine shell fragments, all well rounded and worn, while the bigger shells, as *Gervillia*, etc., are often cemented together. Mixed with this mass we meet large white quartz grains, drifted into it, apparently, from the more distant shore. These different circumstances which have come under my observation throw side-lights on the more estuarine conditions ruling at the time these Permian deposits took place.

I purpose to continue my remarks in connection with this subject at a later meeting.

Professor Boyd Dawkins, in moving a vote of thanks to Mr. Roeder for his very useful contribution, said: I should like to say, for my own part, that I thoroughly welcome this addition to our knowledge. I examined all the evidence many years ago by Slade Lane, and I have been waiting all these years to get a section at right angles to it which would allow of the necessary correction in the geological survey map. The geological survey map, as you know, is largely

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wrong in the Manchester area, so far as relates to the Permian and Upper Coal Measures, and I think that Mr. Roeder's communication will be very useful in rectifying that particular boundary. With regard to the point where Mr. Roeder places a junction between the Triassic sandstone on the one hand and the Permian marls on the other, I fully agree with him. I got that marked down on the six inch map, and I am very pleased to see he has worked out the evidence so well. There is one point on which I should like to say I do not altogether agree with him: that is with regard to the contortions in the Permian marls really belonging to the Permian age. They seem to me rather to be the result of subsequent pressure.

Mr. Dickinson seconded the vote of thanks. He said: Professor Dawkins has given you his view as to the scientific value of the paper; but it has a great practical bearing on the tracing out of the Lancashire coalfield on the dip. We know that these thick limestones which have been discovered correspond with those at Ardwick, and we know that the Ardwick limestones lie, in round numbers, about 500 yards over the Bradford four foot seam of coal, so that the Fallowfield railway cutting gives us actual knowledge of the position of the coalfield at that spot. It is true, as stated in the paper, that we knew this previously by the cuttings that were made for the sewers; but I am not aware that the cuttings for the sewers shewed the actual dip of those Ardwick limestones, overlaid as they are by the moulding sand—that is the Permian sandstone—and above that the Permian marls, and following on with the New Red Sandstone. In the enumeration of these beds I listened as carefully as I could to the ending of this paper, but I did not catch any notice of the bed of conglomerate which separates the Permian sandstone from the Permian marls. It is exceedingly well marked, and is nearly three

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feet in thickness; and if that has not been noticed in the paper I am surprised after such minute sections have been taken.

Mr. HOLLINGWORTH: There is nothing said of conglomerate.

Mr. DICKINSON: It consists of very fine granules of sand. Some of you will no doubt remember, years ago, a valuable paper by Mr. Bradbury—it was read by Mr. Atherton, of Bolton, when the late Mr. Binney was in the chair of this Society—and with it a section was given which appears in our Transactions. It is a section of a bore hole put down at Droylsden; it went down through a part of the New Red Sandstone and through the Permian marls, proving them to be 70 yards in thickness, and underneath them was this conglomerate, one yard; then what is called the Permian moulding sandstone, 250 yards in thickness; and following them are those beds in which the Ardwick limestones lie. It was found that the dip of the upper beds did not correspond with those of the Ardwick limestones. The change of dip took place in passing from one formation to the other. The section now open is exceedingly interesting. How soon it may be soiled over I cannot tell, but I am authorised by Mr. Nowell, the contractor for the formation of the railway from Gorton to Chorlton-cum-Hardy, to say that if this Society should think fit in a body to visit the place he will be most happy to give every means of access and of obtaining information. He will also entertain any application that may be made by the Society to him to see if a portion of that beautiful section could not be preserved for our successors to see as well as ourselves. I do not myself know at the present time where there is another such section open. We used to have a good section up the river Irk; but that is now gone, so far as the marls are concerned. If Mr. Nowell could be induced to preserve so much of

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the section at Fallowfield as would show the marls and the conglomerate which has been referred to, it would, I think, be very desirable it should be done.

The PRESIDENT: I think Mr. Roeder's paper is very interesting from a scientific point of view, and also from the practical one of enabling us to make out where the coal is situated round Manchester. I hope notice will be taken of the invitation which Mr. Dickinson has conveyed to the Society.

This concluded the business of the meeting.

The following are the recent additions to the Library, April to July, 1890:—

Chesterfield and Midland Counties Institute of Engineers: Transactions, Part 6, Vol. XVII., 1890. *From the Institute.*

Cornwall, Royal Institution of: Journal, Part 1, Vol. X. *From the Council.*

Edinburgh, Royal Society of Edinburgh: Proceedings, Vols. XV.-XVI., 1887-8, 1888-9. *From the Society.*

Essex Naturalist: Nos. 10-12, Vol. III., Nos. 1-3, Vol. IV. *From Essex Field Club.*

Glasgow Natural History Society: Proceedings and Transactions, Part 2, Vol. II., New Series, Part 1, Vol. III. *From the Society.*

Hertfordshire Natural History Society and Field Club: Transactions, Part 8, Vol. V. *From the Society.*

Leeds Philosophical and Literary Society: Annual Report, 1889-90. *From the Society.*

Leicester Literary and Philosophical Society: Part 3, Vol. II., 1890. *From the Society.*

Liverpool Geological Association: Transactions, Vol. IX., Session 1888-89 *From the Association.*

London Geological Society: Quarterly Journal, No. 182, Vol. XLVI. *From the Society.*

——— Geologists' Association: Proceedings, No. 6, Vol. XI. *From the Association.*

——— Geological Magazine: Nos. 310-313, Vol. VII. *Purchased.*

——— Institution of Mechanical Engineers: Proceedings, October, 1889, No. 1, 1890. *From the Institution.*

——— Palæontographical Society, Vol. XLIII., 1889. *Purchased.*

——— Year Book of the Scientific and Learned Societies of Great Britain and Ireland, 1890. *Purchased.*

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London.—Geology of the Isle of Wight—Memoirs of Geological Survey, 1889. *Purchased.*

——— Report of British Association, Newcastle-upon-Tyne, 1889. *Presented by the Association.*

——— Royal Society: Proceedings, Parts 287-291, Vol. XLVII. *From the Society.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers: Transactions, Part 5, Vol. XXXVIII. *From the Institute.*

Scotland.—Mining Institute of Scotland: Transactions, Part 9, Vol. XI., Parts 1 and 2, Vol. XII. *From the Institute.*

South Staffordshire and East Worcestershire Institute of Mining Engineers: Transactions, New Series, Vols. III., V.-XI., Vol. XII., Parts 1-2, Vol. XIII., Parts 1-2, Vol. XIV., Vol. XV. *From the Society.*

Yorkshire Geological and Polytechnic Society: Proceedings, Part 2, Vol. XI., N.S. *From the Society.*

Report of the Mossfields Colliery Explosion. By H. Thomas, 1890. *Presented by W. N. Atkinson.*

Report of the Mossfields Colliery Explosion. By W. N. Atkinson, 1890. *Presented by W. N. Atkinson.*

Evidence in Mossfields Colliery Explosion Enquiry. *Presented by W. N. Atkinson.*

Cambridge University: 24th Annual Report of Museum and Lecture Rooms Syndicate.

Devon and Exeter Albert Memorial Museum: Annual Report of Committee, 1890.

Canada.—Geological Society of America: Bulletin, Pleistocene Flora of Canada. By Dawson and Penhallow, 1890. Note on a Fossil Fish and Marine Bone. *From Sir J. W. Dawson.*

Canada.—Montreal: On New Plants from the Erian and Carboniferous. By Sir J. W. Dawson. Pamphlet. *From the Author.*

Ottawa.—The Canadian Mining Review: Nos. 3-6, Vol. IX. *From the Editor.*

Geological and Natural History Survey of Canada: Annual Report, 1887. Parts M and K. *From A. R. C. Selwyn, F.R.S., Director of the Survey.*

Nova Scotia.—Halifax. Nova Scotian Institute of Natural Science: Proceedings and Transactions, Parts 1 and 3, Vol. VII. *From the Institute.*

U.S.A., Chapel Hill, North Carolina: Elisha Mitchell Scientific Society, Part 2, Vol. VI. *From the Society.*

——— Harvard College, Bulletin of the Museum of Comparative Zoology:

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Nos. 1-4, Vol. XIX., No. 1, Vol. XX., Nos. 7-8, Vol. 16. *From Alexander Agassiz.*

U.S.A.—Indianopolis, Geological and Natural History Survey of Indiana: 15th Report of the State Geologist. *From John Corlett.*

——— Minneapolis, Geological and Natural History Survey of Minnesota: 17th Annual Report, 1888, Bulletin No. 5, Natural Gas in Minnesota, Bulletin No. 1, History of Geological Survey, Minnesota. *From the State Geologist.*

——— New York, American Museum of Natural History: Bulletin Nos. 2-3, Vol. II, 1890. *From the Trustees.*

——— Pennsylvania Geological Survey: Parts 2, 3, and 5, 1889. Atlases of Anthracite Field. *From the Board of Commissioners.*

——— Philadelphia, Academy of Natural Sciences: Proceedings, Part 3, 1889. *From the Academy.*

——— Philadelphia, Journal of Franklin Institute: Nos. 772-774, Vol. CXXIX., No. 775, Vol. CXXX. *From the Institute.*

——— San Francisco, Californian State Mining Bureau: 9th Annual Report, 1889. *From the State Mineralogist.*

——— Scranton, Pa., The Colliery Engineer: April to July, 1890. *From the Editor.*

——— Washington, United States Geological Survey: 7th Annual Report, 1885-6. *From the Director of the Survey.*

India, Calcutta: Records of the Geological Survey of India, Parts 1-2, Vol. XXIII. *From the Government.*

Sydney, Geological Survey of New South Wales: Records, Vol. 1, Part 3, 1889. *From the Hon. the Minister of Mines.*

Berlin, Verhandlungen der Gesellschaft für Erdkunde: Nos. 3-5, Band XVII., Zeitschrift, No. 144, 1890. *From the Society.*

Dresden, Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden, 1889. *From the Society.*

Paris, Annuaire Géologique Universel, 1858. *From Docteur Dagincourt.*

Pisa, Atti della Società Toscana di Scienze Naturali: Processi Verbali, Vol. VII., 1890. *From the Society.*

Roma, Atti della Reale Accademia dei Lincei: Rendiconti, Fasc. 4-9, Vol. VI. *From the Academy.*

St. Petersburg, Academie Impériale des Sciences: Memoires, Parts 4, 6, and 7, Tome XXXVII. *From the Academy.*

——— Institut des Mines, Comité Géologique: Mémoires, Vol. IX., No. 1; Bulletins, Parts 6-8, Vol. VIII. *From the Minister of Domains.*

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